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Value Analysis

STEADILY rising costs of material and labour have long focused a great deal of attention on proper material selection and on higher manufacturing efficiency. More recently there has been increasing recognition that production costs are as dependent on good design as they are on material economy and manufacturing competence. One way in which reduction of production costs can be approached is through "value analysis," a technique whose functions and achievements were described by J. Rawicz-Szczerbo, in a recent Paper presented to the Institution of Production Engineers. Briefly, value analysis is a specialist activity whose aim is to secure equal or better quality of the product at a minimum cost; not, be it noted, merely cost reduction for its own sake but better value for money.

Spectacular results have already been achieved in American and British organizations who have adopted the technique. Thus, the General Electric Company of America, who were the pioneers in this field, report saving several million dollars annually over the last ten years; the U.S. Navy, which established a value analysis department four years ago, saved over $18,000,000 in the first year and greater amounts since; while in this country the Joseph Lucas (Electrical) Co. Ltd. report savings of between £70,000 to £100,000 annually, and the G.E.C., in their fractional horse power motor factory, savings at the rate of £37,000 a year; this last on products which, for the most part, had already been well designed for production.

The method of value analysis is to study in detail those features which contribute to the cost of any material, component, operation, process, or product in order to determine whether they are fulfilling their functions economically, or whether those functions can be performed more cheaply by some other means. Five stages are involved. First, the collection of all the facts about the product, i.e. drawings, specification, manufacturing methods, quantities, sources of supply and accurate costs. Secondly, identification of the functional areas into which all the components fall and decision as to whether the components are worth their cost. In the third stage, ideas for cheapening the product are generated and collected together, these, in the fourth stage, being analysed to see whether they will work and whether they will actually save money. Finally, a report is prepared on the worthwhile suggestions, listing any savings that they will achieve.

A variety of other services can also be rendered by a value analysis department in the course of its activities. Thus, existing and new products can be analysed, advice can be given to designers as to which of a number of functionally acceptable designs will be the cheapest, to buyers by pointing out purchased items which seem to cost too much and providing them with information which will help them in their negotiations with suppliers, and to suppliers themselves on how their manufacturing costs may be reduced. A value analysis section can also foster and reinforce a cost-conscious attitude in the company by issuing information on new materials, processes and tools; in fact, any details which might help designers, buyers and others to reduce the costs of activities under their control.

It is not claimed that value analysis is the panacea for all troubles, nor that its aims are new. What is new is its approach, in that it consists of a specialized, carefully planned and intensive attack on product costs, but *not* at the expense of quality. The measure of its success is shown in its results.

Out of the MELTING POT

Etched Strength

SOME interesting observations have recently been reported on the effect of environment on the fracture strength of single-crystal germanium rods. The first experiments, in which such rods were stressed as beams using four-point loading in air, water and various etchants, showed that certain etching treatments were able to increase the fracture load very considerably. This effect is different from that known as the Joffe effect, in which some brittle materials, such as rock salt, become plastic if tested while dissolving. In the case of germanium, no plastic flow was observed. The increase in fracture stress was found to depend on the rate of etching. Thus, in one series of experiments, in a mixture of hydrofluoric acid and nitric acid the rate of etching was varied by varying the proportion of hydrofluoric acid. As the rate of etching increased, the fracture strength rose rapidly from the value of 7 kg/mm^2 characteristic of the rods in air, to reach a maximum of 48 kg/mm^2 at an etching rate of about 0·15 mm/hr. As the etching rate was increased still further, the fracture stress fell off gradually, finally reaching an almost constant value of about three times the fracture stress in air. The increased fracture stress could be observed only if the etching was actually going on, or if the specimens were protected from air, e.g. by immersion in water, after etching. Exposure to air caused the strength to revert to that of the specimens in the original unetched condition. It was noted that the enhanced fracture stress of 48 kg/mm^2 was below the 130 kg/mm^2 which had been reported for germanium whiskers. In more recent experiments, in which the germanium specimens were immersed and tested in a chemical etching and polishing solution (CP-4), fracture stress values as high as 300 kg/mm^2 were obtained in spite of the fact that the cross-sectional area of the specimens was ten thousand times larger than that of the whiskers ($5{\cdot}75 \times 10^{-1}$ mm^2 as compared with $7{\cdot}85 \times 10^{-5}$ mm^2). Another interesting effect was that when such specimens fractured they broke into many small pieces (about 100 or more). By way of explanation, it is suggested that crack networks are present prior to fracture. When one such crack fails, the resulting shock wave supplies additional energy for the growth of others. The increase of the fracture stress to near the theoretical value by the etching is due to the continuous removal of the surface preventing shallow cracks from developing to a critical size.

As They See It

IT is instructive to compare and contrast the interest shown in maintaining and strengthening a link between everyday interests and an interest in science and its progress, and, on the other hand, the lack of interest which is allowed to persist and develop in the connection between this progress and those responsible for it. Why this lack of acknowledgment of the human side of scientific research and development? Consider the contrast. In the one case a good deal of effort is being expended on trying to bring home the message that developments in science, however remote some of them may appear, are of vital concern to each one of us. By contrast, and by default, one is left with the impression that the mutual connection between these same developments and those who bring them about is of little or no importance. A few names are high-lighted, but even in those cases they are usually left to evoke nothing more human than scientific supermen. All the other day-to-day progress is increasingly the work of shadowy scientists or, worse still, of impersonal research teams. Signs of discontent over this state of affairs, and of a desire for personal recognition and for a closer identification with the work, are not lacking. Obviously a remedy is not to be sought in according film-star treatment to scientists. An over-all consideration of the two situations that have been contrasted suggests that the requirements of both—an appreciation of the general importance of science and scientific progress, and of the research workers' side of research work—could probably best be achieved, not as at present by overstressing the one and overlooking the other, but by concentrating on the research workers' interest in their research. It is only this kind of interest, not an artificially fostered disembodied "interest in science," that is likely to prove infectious.

Probable Path

ABSTRACTS, like everything else, sooner or later, will have had their day. Not that abstracts will cease to be prepared, but both their form and their purpose will have altered from those that are so familiar to-day. A number of factors operating to bring about such changes can already be discerned. There is, for a start, the progressive change in the material that is normally abstracted. Slowly but surely, more and more of this material is shrinking in size and is gradually approaching the form and size of current abstracts. Pressure on space, the realization that time available for reading is limited, and developments in writing, editorial, typographical and layout skills are all combining to increase the attractiveness of such material, and the ease with which it can be absorbed; reading, in the now almost old-fashioned sense of steadily plodding through a solid chunk of printed matter, is no longer the apposite word. Another factor is provided by some recently obtained evidence that shows, what has long been suspected, that abstracts are not a substitute for the reading of original literature. A survey of a number of research scientists indicates that those with more original work and inventions to their credit are also those who do more browsing through the literature and rely less on abstracts and the services provided by libraries and information departments. Faced with the growing attractiveness and effectiveness of original material, those responsible for the preparation of abstracts persist in clinging to the concept of abstracts as a bibliographical tool, and in failing to consider the repulsive appearance of the finished products. Moreover, current trends, interests and inclinations in the abstracting field suggest that matters are likely to get worse. Machinery is already here and there rearing its ugly head. Still widely scoffed at by the "luddites," machinery will undoubtedly take the same all-conquering course in this field as it has in all the others into which it ever gained admittance. The step from the concept of a bibliographical tool to a bibliographical machine tool should, after all, not take very long, by which time abstracts, as we now know and dislike them, will have passed from the literary scene.

Skimmer

VACUUM HOT-PRESSED SLAB — ROLLING, EXTRUSION AND MACHINING

Fabrication of Beryllium

By K. G. WIKLE

In this article, which is a shortened version of a Paper presented to the American Society of Tool Engineers, the author, who is associated with the Brush Beryllium Company, discusses methods used to fabricate beryllium into primary shapes and final useful forms, limitations of application and programmes being carried out to exploit further its structural use.

WITH a lightness equal to that of magnesium alloys, a stiffness 50 per cent greater than that of steel, a useful structural range above the melting points of aluminium and magnesium, along with excellent electrical and thermal conductivity and high heat capacity, beryllium is a metal of great interest to the designer of air and space craft. In spite of these attractive properties, beryllium metal has not, in the past, been extensively used in airborne structures for several reasons:

(a) Lack of commercial availability as sheets, extrusions, forgings, castings, etc.

(b) The consequent lack of sufficient engineering property data on structural beryllium to enable its intelligent incorporation into design.

(c) Inadequate development of structural fabrication technology, i.e. forming, joining, surface finishing, etc.

(d) Problems associated with the lack of three-dimensional ductility in beryllium.

(e) Fear of inadequate source of supply.

(f) Cost.

(g) Toxicity.

Sintered Beryllium

Good mechanical properties, as well as good fabricability in beryllium, depend upon a material with a fine grain size and a dense uniform structure. Although beryllium is relatively fusible (melting point, 1,284°C.), casting techniques have not been devised to produce on a commercial basis a consistently sound, dense ingot with a uniform and fine-grained structure. Dense beryllium with a fine grain size was produced at the Brush Beryllium Company as early as 1946 by crushing beryllium pebble derived from the reduction of beryllium fluoride with magnesium, and pressing under vacuum.

Present production technique consists of (1) vacuum melting beryllium pebble, largely to remove slag and magnesium, and (2) casting into ingots. The ingots are chipped up by a multiple turning operation (Fig. 1) and then comminuted into −200 mesh powder between beryllium attritioning plates (Fig. 2). Beryllium powder may be fabricated into dense, fine-grained bodies by any one of the following processes:

(1) Vacuum hot pressing. (2) Hot pressing (in air or inert gas). (3) Vacuum sintering to shape (no compaction during sintering). (4) Cold and/or warm compaction followed by sintering and coining. (5) Cold and/or warm compaction, followed by hot extrusion or hot pressing.

Of these, only vacuum hot pressing is used extensively in the beryllium industry. The process consists of loading beryllium powder in steel or graphite dies (Fig. 3), and with a vacuum of about 50 microns and a compacting pressure of about 50 to 250 lb/in^2, the powder is consolidated at 1,050°C.-1,100°C. to essentially theoretical density (Fig. 4). The usual commercial product is now a large block, measuring up to 4 in. by 24 in. by 51 in. and weighing up to 325 lb., although cylinders and conical and spherical shapes measuring larger than 4 ft. in diameter and weighing up to 2,000 lb. are being successfully vacuum hot pressed in production.

Beryllium blocks made by vacuum hot pressing are fine grained, dense, sound and uniform in structure. The material is easily machined and can be further fabricated by rolling, extrusion or forging to develop improved mechanical properties and desired shapes. Perhaps the most valuable characteristic of vacuum hot pressed beryllium is that the properties (unlike all mechanically-worked metal which is strongly directional), are quite isotropic and independent of the direction of testing. This appears to be a function of the rather low compacting pressures used and the random orientation of the original powder particles.

Wrought Beryllium

The standard commercial beryllium described above has limited although satisfactory ductility at room temperature, because the weak fracture planes (basal) are readily available for failure in randomly oriented grains. However, if this material is heated above 455°C., the basal planes develop stronger bonds, and further slip systems become available to accommodate deformation in the metal. Thus, plastic working of beryllium is possible substantially at a temperature above 455°C. Since the metal can recrystallize as low as 750°C., the range of 455°-760°C. is called the *warm working* range, and 760°C. and above, the *hot working* range. As would be expected, it is possible to *warm* extrude, roll, forge or form beryllium, as well as *hot* extrude, roll, forge or form the metal. Warm working is similar to cold working, since the yield strength is

Fig. 1—Multiple tool turning operation for chipping beryllium vacuum cast ingot

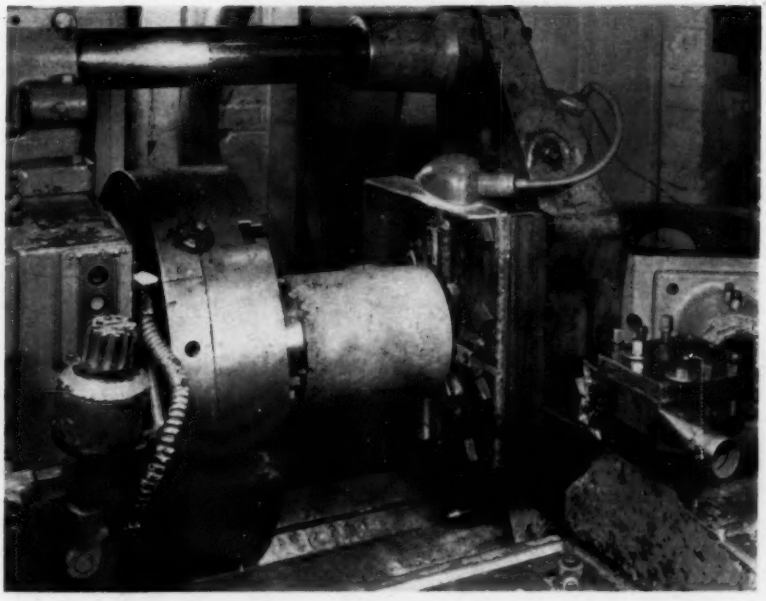


Fig. 2—Attrition mill and shaker screen for comminuting beryllium metal chips into —200 mesh powder

increased with some loss of tensile specimen ductility, and there are limits to the degree of warm working possible before failure. In hot working wrought vacuum hot pressed beryllium, it is usually not desirable to exceed about 845°C., since above this temperature grain growth and a diminution of mechanical properties occur.

In extruding, rolling, forging and forming beryllium, it is the usual practice to stay at 760°C. or lower when working with bare metal, to prevent oxidation and scattering these oxidation products around. If higher temperatures are used, the metal is either clad, coated, or handled in an inert atmosphere.

Extrusion

Extrusion is commonly carried out in three temperature ranges, i.e. 455°-680°C., 730°-820°C., or 900°-1,150°C. The first range is called warm extrusion, and has been carried out so far on small billets of $2\frac{1}{4}$ in. dia. and smaller, and at low reduction ratios, 9 to 1 and less. Well-aligned and precision-fitting containers, rams, dies, and billets are used, along with graphite or molybdenum disulphide lubrication. Pressures of 40 to 100 tons/in^2 are developed. The second range is called "bare" hot extrusion. Beryllium is coated with glass or salt lubrication, and extruded similarly to titanium or steel in the Ugine-Séjournet process. Reductions of from 9-1 up to 16-1 have been used. The third range is called "hot" extrusion and the beryllium is clad in steel for oxidation protection and to prevent galling of the dies. Reductions of as high as 40-1 have been frequently used. Cold-pressed or warm-pressed powders may be extruded directly and yield metal having the optimum mechanical properties. A variety of shapes has been produced by extrusion, including rods, squares, flats, tubing, H sections (Fig. 5). The intermediate range extrusion process appears to

Fig. 3—Filling vacuum hot-pressing die (steel) with —200 mesh beryllium powder from blending drum

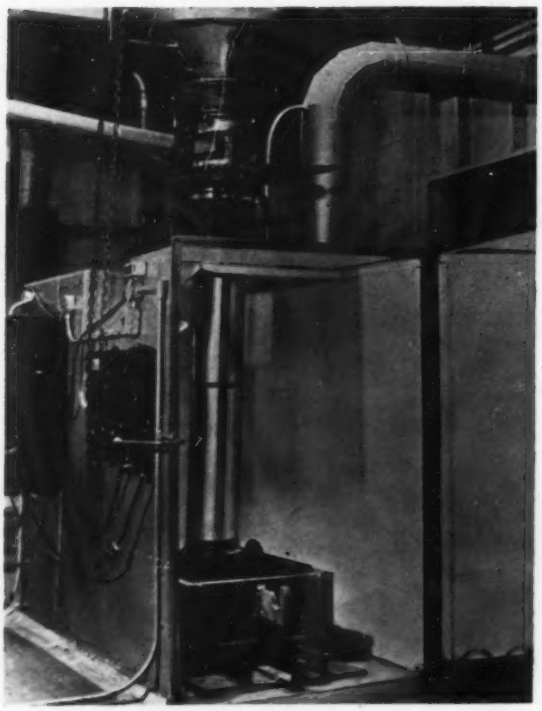
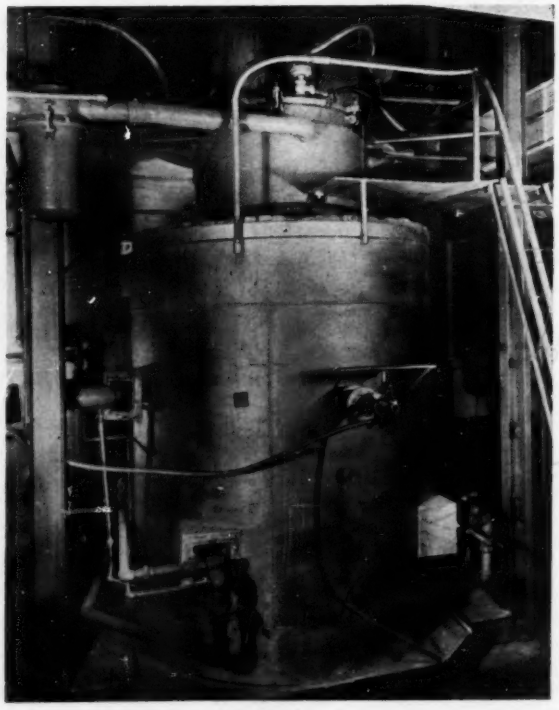
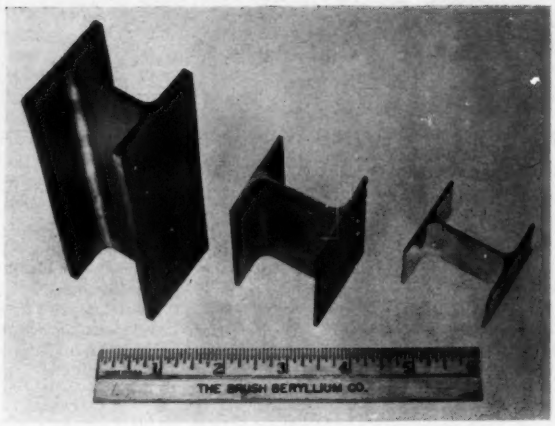
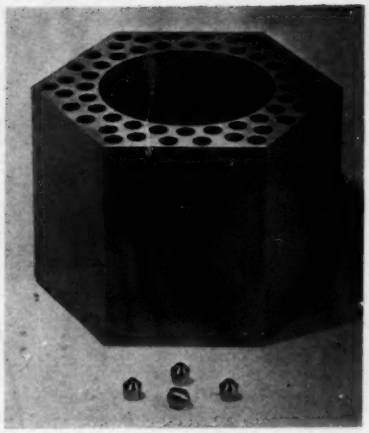


Fig. 4—Gas-fired vertical vacuum hot-pressing furnace for compact-sintering of beryllium powder





Left: Fig. 5—H-shape extrusions fabricated from commercial beryllium billets in the intermediate temperature range, 730°C. to 845°C., using glass lubricant



Right: Fig. 6—Hexagonal nuclear reactor shape machined from vacuum hot-pressed beryllium

offer the best combination of shape versatility and mechanical properties.

Rolling

Rolled plate and sheet are fabricated from commercial beryllium block. Since wrought beryllium will develop large recrystallized grains above 845°C., rolling is performed below this temperature and above 455°C. To minimize oxidation, to maintain uniform temperature, and reduction, and to prevent "alligatoring," i.e. splitting down the centre plane, the sintered blocks are jacketed in heavy steel assemblies and rolled down to about $\frac{1}{8}$ in. The beryllium is then pack rolled similarly to titanium, and bare rolled down to thicknesses as thin as a few mils. Current production at the Brush Beryllium Company includes sheet and plate up to 30 in. wide and 5 ft. long.

Forging

This operation is still in the development stage, but press forging at 730°-845°C. appears to be possible.

Machining

Interest in beryllium has been fostered by nuclear reactor demands for relatively massive parts having uniform and optimum nuclear properties, but no serious demands on mechanical properties. To make such parts, a readily-machinable material was needed, and vacuum hot-pressed metal met these requirements well. Three machined parts are illustrated in Figs. 6, 7 and 8.

The machinability of beryllium compares favourably with that of heat-treated aluminium castings, although the beryllium metal is more brittle and abrasive. About 1 h.p./in^3/min. is normally required for machining beryllium. Machined chips are well broken and do not obstruct the work on the cutting tools. Rake angles, cutting speeds and cutting fluids, which exert major influences on the chip formation when machining other metals, have little influence when machining beryllium chips.

Standard tools, jigs and fixtures such as are used for aluminium or steel can be used on beryllium metal. Wherever possible, carbide tipped tools of grade 44A should be employed for interrupted cutting, and of grade 883 for continuous cutting, in order to obtain longer tool life.

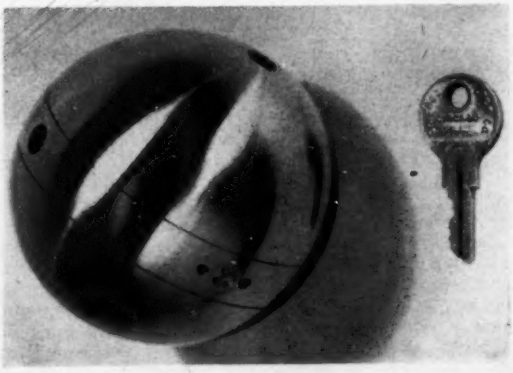
Optimum tool life and chip formation are attained if back rake angles are held to 0° and side rake angles to 7°. Relief angles from 7° to 10° keep the tool flanks from rubbing on the work, and minimize the adherence of chips to the tool. The side cutting edge angles are not critical, but should not exceed 10° to prevent chatter. The nose radii on all tools should be kept relatively small to prevent chatter, i.e. $\frac{1}{64}$ in. rad. to $\frac{1}{32}$ in. rad. for continuous cutting, and $\frac{1}{16}$ in. rad. for interrupted cutting. Tools should be resharpened when slightly dull, to maintain good cutting edges and conserve tool material.

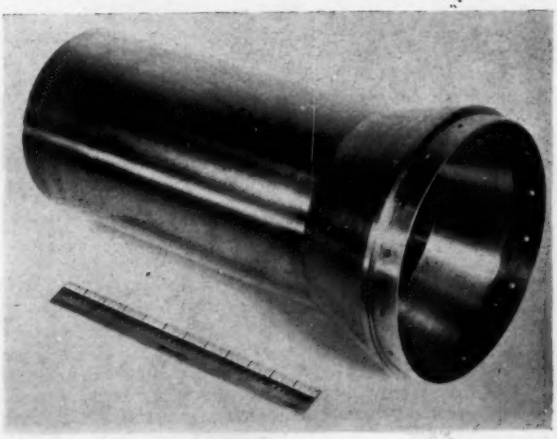
The use of cutting fluids when machining beryllium is primarily to cool the work, wash away chips, and lay metallic dust when grinding, drilling, or sawing. Ordinary soluble oils or emulsions may be used consisting of mixtures of one part oil to 20-30 parts water, for milling, sawing and drilling, or for grinding mixtures of one part oil to 30-50 parts water.

A wide range of cutting speeds, feeds and depths of cut is possible in turning and boring of beryllium. Selection of the cutting speed may depend solely on auxiliary factors, for lower speeds are necessary for clean chip salvage, dust disposal, etc., although the maximum speeds which the work and tools would allow are much higher. Depending on the shape and size of the work, as well as

Below: Fig. 7—Spherical gyroscope part machined from vacuum hot-pressed beryllium

Right: Fig. 8—Tube shield support machined from vacuum hot-pressed beryllium





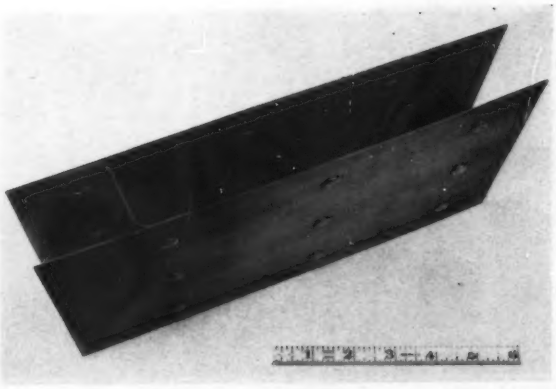


Fig. 9—Z section compression panel made from 0·050 beryllium sheet

proper chucking, surface speeds of 150-250 ft/min. are practicable.

Deep cuts can be taken provided the work is of sufficient size and is properly chucked. Heavy feeds provide a quick means of removing metal, but should not be over 0·015 in. to prevent too rough a finish or break out on the edges. Extremely fine feeds should be avoided, inasmuch as they tend to dull the tool faster and heat the work more than heavier cuts.

As in turning, milling speeds have to be governed by proper chip disposal and control of airborne dust. As an example, using a 6 in. diameter face milling cutter with 10 Carboloy-tipped inserted cutter blades, approximate spindle speeds should equal 60-100 r.p.m. for roughing cuts, and 100-150 r.p.m. for finishing cuts. Table feeds in in/min. should be 3 in.-6 in. for roughing and 3 in.-6 in. for finishing at finish cutting speeds. At these rates, with a good fitting hood around the tool, dry chips are properly collected through air exhaust chip collectors.

Recommended drilling speeds are 70-100 surface ft/min. with feeds of 0·001-0·002 in. per rev. for drills under $\frac{1}{8}$ in. diameter, 0·002-0·004 in. feed for $\frac{1}{4}$ in. diameter, and 0·005 in. feed if $\frac{1}{2}$ in. diameter drills are used. Standard high-speed drills with 118° included point angle are reground to 90° to give satisfactory operation.

In band sawing, good results with small material losses are achieved on Do-All saws.

Finish grinding of beryllium metal is often unnecessary, inasmuch as finishing cuts by machining will give smooth surface finish if the machine tool equipment is in good condition.

Grinding is necessary on beryllium shapes requiring sharp edges and close tolerances. Since beryllium metal is non-magnetic, the problems of holding the work on a surface grinder are the same as those for holding brass or aluminium.

Aluminium oxide wheels with vitrified bond, coarse-grained, and of a hardness such as Norton's A 24 J 5 VBE (soft) are recommended for rough grinding. Wheels of medium grain—soft to medium hard—such as Norton's A 60 K 5 VBE are recommended for fine finish grinding, especially for rough and finish centreless grinding of extruded beryllium metal rods. Coolant may be applied in a heavy spray to precipitate grindings and dust into sludge. It is essential that all grinders be properly hooded for efficient air exhaust to remove airborne dust. Sludge which collects under the liquid in the pit or on machine surfaces should be removed frequently.

Beryllium bars, tubes and shapes may be cut rapidly and accurately to length within a tolerance of +0·005 in. on abrasive cut-off machines. Abrasive discs, such as 10 in. diameter × 0·050 in. thick, C 46 F—R 70, will cut up to $2\frac{1}{4}$ in. diameters. A recommended rate of cutting off is approximately 1 in²/min. Abrasive cutting is also recommended for sawing sheet and plate to size.

Machining Precautions

Precautions are necessary in beryllium machining operations, both for the purpose of securing clean, uncontaminated beryllium chips and in order to avoid atmospherical dispersal of beryllium in the working areas. If operations involving preparation of machined parts from hot-pressed billets are carried out dry, the chip is of such quality that, unless inadvertent contamination has taken place in machining, it may be converted directly back into powder and recycled into the fabrication stream for preparation of new hot-pressed billets. Consequently, for overall economic machining of beryllium, extreme care must be taken to conserve chip cleanliness and value, as even slightly contaminated chip undergoes a devaluation of up to 75 per cent as compared with clean chips suitable for direct repowdering.

Dust should be continuously removed from all working areas through a central exhaust ventilating system. In conjunction with the exhaust system, hoods should be used to enclose each machining operation. These should be of such design as to create a rapid flow of air from the room and over the work surface, carrying airborne dust directly through the exhaust system to a dust collector.

Hood installations should be continually checked by means of portable air samplers to assure continuance of an effective air flow. Air samples should be taken at regular intervals throughout the shop to measure the beryllium content in the air, which should be held at a concentration not greater than 2 micrograms/M³ (0·01 micrograms/M³ outside) as prescribed by the Atomic Energy Commission regulations.

The lathes and milling machines may be equipped with special chip collectors, designed to discharge beryllium chips into 55-gallon drums. This chip pick-up system assures that the machine and chip pan areas are kept free from dust-forming chips.

Forming

Beryllium sheet, plate and strip can be hot-formed at 370°C. and above into typical airframe shapes, such as angles, channels, Z-sections, as shown in Fig. 9. Most consistent success is obtained at 540°-820°C. Before forming, the part should be inspected for scratches, cuts, dents, and other rough conditions, and good surfaces and edges prepared. Using a red heat makes it quite easy to ensure that the operation is being carried out at a satisfactory temperature. Below 540°C. a minimum bend radius of four times the thickness should be used, while above this temperature, down to two times the thickness has been used on $\frac{1}{16}$ in. thick stock. Such operations as shearing and punching can be carried out at 430°C. and above on $\frac{1}{8}$ in. and thinner stocks. It is preferable to carry out hot-forming and cutting operations at relatively slow speeds, and to anneal at 760°C. afterwards, or between steps in extensive deformation operations.

Joining

Riveting and bolting are used for joining beryllium to itself and other metals, but care in the accurate preparation of holes having a good finish is necessary. Care must also be exercised not to bend the components seriously while pulling them together. Holes should be well aligned, and faying surfaces of close matching contour. Mechanical joints under simple compression or tension can deform considerably before failure.

Techniques for soft soldering and brazing have been established, and are being carried out on a production basis at present. Fusion welding, braze welding and resistance welding all have been successfully performed but are still in the development stage.

Soft soldering can be easily carried out if proprietary soldering compounds are used, and if instructions are followed. Surfaces that are to be joined are first tinned by applying compound and heating to the recommended temperatures. The excess flux is washed off in warm water. More compound is applied to the joints, they are assembled, and parts are heated to the recommended temperature. The joints

are checked while at temperature to see if parts are properly joined. Excess flux is again washed off in warm water.

Furnace brazing, i.e. joining beryllium to itself and to other metals by means of the melting of a third component between the two pieces to be joined, is accomplished in a controlled temperature and atmosphere furnace. Brazing materials that are used are usually silver or silver-copper alloys, although aluminium and aluminium-silver have also been used. The braze material is preplaced in clean joints and the joint is brought, in hydrogen, inert atmosphere or vacuum, up to the flow temperature long enough to cause melting and flow. Rapid heating and cooling should be used with copper-alloy braze material to prevent excessive intermetallic compound formation and to prevent excessive diffusion. Lap joints are the easiest type of joint to make, but are least desirable because of the notch effect which is inherent in them, reducing the mechanical reliability of the joint. Step joints, scarf joints and butt joints are of more preferred design.

In braze welding, the braze material is used as a filler material and is applied by an arc or an oxy-acetylene torch. Until recently, only aluminium and its alloys have been used successfully as filler material, with best results with a 12 per cent silicon-aluminium alloy. Newer brazing alloys are being developed at present which have higher strengths. The consumable arc-inert gas shield process yields better braze welds than either covered electrode or tungsten arc welding, as oxidation ahead of the pool is much less in the first method.

Although still in the development stage, fusion welding, using beryllium filler metal, has given very encouraging results. Weld cracking, oxidation, gassing and porosity have been the major problems. Welding is performed with a tungsten arc under inert gas using a beryllium filler rod. Metal to be joined must be heated to 540°C. or above to minimize thermal shock. Complete penetration during welding with no discontinuities must be obtained for a successful weld. Cracks seem to be initiated from such discontinuities because beryllium is highly notch sensitive. Highly restrained joints are to be avoided in welding, as well as other forms of joining, because of the danger of cracking. Any preferred crystal orientation at the point of the weld is lost, affecting the metal properties accordingly.

Treatment Processes

Because of the high modulus of elasticity in beryllium, even small strains produce large stresses. This, coupled with the notch sensitivity of beryllium, means it is important to stress-relieve beryllium after fabrication processes. Recrystallization annealing is accomplished by heating to 750°-760°C. It is best not to exceed 820°C. to avoid the possibility of grain growth, which will seriously reduce the mechanical properties. Heating to 455°-730°C. will help alleviate stresses without causing recrystallization.

Beryllium may be sand blasted or grit blasted if proper ventilation and blast product disposal are available. However, oxidized surfaces may be cleaned by immersion in dilute inorganic and organic acids. A sulphuric-phosphoric-chromic acid solution may be used to give a more stringent attack and for a highly reflective, grey appearance. This solution may be made up as follows:—26·5 mL H_2SO_4, 450 mL H_3PO_4, 53¼ gm. CrO_3.

Add the CrO_3 to ortho-phosphoric acid, heat to about 150°C. to dissolve the CrO_3 flakes. Let cool to 110°C. and add H_2SO_4. Use at 110°C.

Men and Metals

Now 82 years of age, **Sir Ernest Canning,** chairman of W. Canning and Company Limited, is to retire from that position and from the board of directors at the end of this present year. By his retirement, Sir Ernest will end a family association with the company in Birmingham which has existed for over 150 years. On leaving King Edward's School, Aston, in 1892, he joined a subsidiary company of

Canning's in Birmingham — T. L. Hemming — and later joined his brother in partnership. On the retirement of his brother in 1918, Sir Ernest became the head of the company. In 1920 the business was converted to a limited liability company, with Ernest Canning as chairman and managing director. In 1939 he was knighted in recognition of his political and public services. On his retirement, Sir Ernest will be succeeded as chairman by **Mr. F. H. Ewens,** who will also continue as managing director. It is understood that **Mr. W. H. Griffin** has been appointed joint managing director with Mr. Ewens, and that **Mr. B. Tromans,** who has been associated with the chemical division of the company for a number of years, has also been appointed to the board. It is proposed to alter the company's Articles of Association in order to permit the board to confer on Sir Ernest the title of President of the company.

It has been announced by Steele and Cowlishaw Limited that **Mr. F. Limb,** O.B.E., has resigned from the position of managing director but will remain on the board of the company. He is succeeded by **Mr. J. B. Capey,** previously director and general manager.

At the annual dinner of the **Worshipful Company of Founders,** held at the Mansion House, London, on Thursday of last week, the Master of the Company—**Mr. G. W. Ilsley**—in the presence of the Lord Mayor and Sheriffs of the City of London, presented the Founders Company Medal, cast in bronze, to each of four Liverymen of the Company to mark their services to the Art and Mystery of Founding and to the Company. The awards were made to **Dr. J. G. Pearce,** C.B.E., and **Dr. J. E. Hurst,** C.B.E., J.P., in appreciation of their help to the Company in the formulation of the Founders Company Fellowships and the administration of them since their inception. The other two medals were presented to **Mr. C. C. Booth,** J.P., and **Mr. J. J. Sheehan,** B.Sc., for their valuable services to the Company.

Staff appointments recently made by G. A. Harvey and Company (London) Limited are as follows:—**Mr. K. Tardiff** to be home sales manager; **Mr. H. Barker** to be export sales manager, and **Mr. H. F. Jones** to be London area manager. The first two gentlemen will operate from the company's head offices at Greenwich, and Mr. Jones will be in charge of the London sales office.

Joint managing director of Imperial Chemical Industries Limited, Metals Division, Witton, since 1952, **Mr. M. J. S. Clapham** has recently been appointed a member of the Government Committee of Enquiry into the organization of youth services. He has always taken a keen interest in education and employment matters. He served on the Birmingham Education Committee from 1949-56, and is now a member of the Council of Birmingham University and of the West Midlands Advisory Council for Technical, Commercial and Art Education and Regional Academic Board. At the Duke of Edinburgh's Conference at Oxford in 1956, he was chairman of one of the twenty study groups. A vice-president of the British Non-Ferrous Metals Federation, he was appointed in 1957 to the Council of the Birmingham Chamber of Commerce.

Research Progress

IN our issue of December 19, an article appeared on p. 512 entitled "Titanium Alloy Development." In several of the alloys mentioned the symbol Be was quoted; this should, in fact, have appeared as Ge. Similarly, "beryllium" should have read "germanium."

Products and Processes

TRENDS IN THE DEVELOPMENT, APPLICATION, PROCESSING, DESIGN AND WORKING OF NON-FERROUS METALS AND THEIR PRODUCTS

Titanium Heating Coils in Chrome Vats

HEATING chrome plating vats has always been one of the electroplating engineer's worst headaches. The usual method is by means of an external jacket carrying hot water or steam. A more convenient way of keeping the solution at working temperature would be to immerse a steam heating coil in the vat, but conventional materials, including plain, antimonial, or tin-bearing lead, give poor service owing to chemical attack, often accompanied by mechanical damage. This explains the increasing use which the plating industry is making of coils made from titanium tubing, which is available in a variety of diameters and gauges. Titanium is completely inert to chromic acid, hot or cold, and steam coils with a wall thickness of the order of 20 S.W.G. will last indefinitely. Users have reported that vats can be heated with titanium coils in 25 per cent less time than with lead coils of the same size.

The strength and lightness of titanium make simpler designs possible; supporting struts are usually unnecessary, and a titanium coil weighing only 5 lb. or 6 lb. has the same heat transfer capacity as a lead coil weighing about 1 cwt. Although titanium is a much more expensive material, because it is so easy to fabricate and because the components can be made many times lighter than in lead, in actual practice a titanium steam coil for a given duty costs little more than a lead one and lasts much longer in service.

Simple units not requiring welding can be made from I.C.I. titanium tubing by anyone with a little experience in the bending of light-gauge tube, and more complex coils can be obtained from fabricating firms equipped with Argon-arc welding facilities, or as standard items from manufacturers of electroplating plant.

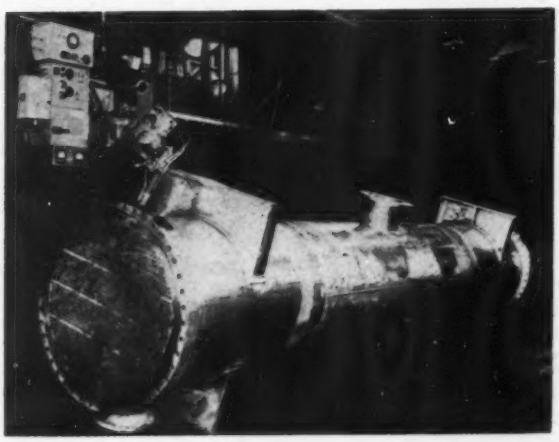
Welding Aluminium Heat Exchangers

HEAT exchangers, whether made from ferrous or non-ferrous alloys, present a number of welding problems, and the use of Sigma welding has reduced costs, in one instance, by 45 per cent, and increased production speed.

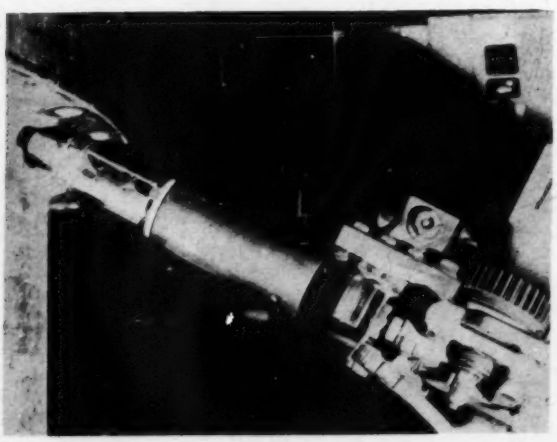
Welding speeds averaging 25 in/min. (63·5 cm.) were attained when an automatic SWM-3 Sigma welding machine was used in the production of an aluminium heat exchanger. Previously, this type material had been manually welded.

Because of special positioning requirements, a cold-wire feed drive unit is used rather than the regular SWM-3 head. In addition, a Heliarc HW-12 nozzle is attached to the standard HW-16 torch in order to increase welding speed in confined areas. The X-ray quality welds produced with this argon-shielded process are made with Oxweld No. 23 aluminium wire. Equipment of this type is a product of the Linde and Alloys Department, Union Carbide International Company.

Making the final pass on a fillet weld between shell and flange on an aluminium heat exchanger



Close up of the standard Heliarc HW-16 torch, equipped with an HW-1 nozzle for work in confined areas



Alkaline Tin Plating

AT present known chiefly for its use in the immersion plating process for the tinning of aluminium pistons, and also used in electro-tinning, potassium stannate provides certain advantages in both immersion plating and electroplating. In the tinning of aluminium pistons, for instance, the use of potassium stannate instead of, as at present sodium stannate, makes it possible to achieve substantial reductions of sludge formation together with much improved analytical control limits. Plating baths can be operated continuously, and far less time will be spent by operatives in the control and maintenance of the bath.

In electroplating, solutions containing potassium stannate will have a far greater electrical conductivity than a similar solution containing the same concentration of sodium stannate. This means that higher current densities are obtained for a given voltage, so that conditions are ideal for barrel plating. Alternatively, a dilute potassium stannate solution can give the same plating rate as a more concentrated one containing sodium stannate, so that wastage by dragout, and initial costs, are reduced considerably.

The economic advantages of using potassium stannate are considerable. As a result of the cut in the rate of sludge formation, an all-round saving on plant maintenance can be achieved.

As the result of negotiations with the Metal and Thermit Corporation of New York, Albright and Wilson (Mfg.) Ltd. have announced that they will be the main suppliers of potassium stannate in the United Kingdom.

They have also been licensed by Metal and Thermit to supply "High Speed" tin anodes. One of the main difficulties associated with alkaline electro-tinning is in maintaining the film on the surface of the tin anode. If this film is not present it means that the anode is either dissolving too slowly or too fast. As a result, the bath will not operate properly. This is often due to insufficient room in the electrolyte for enough surface area of the anode to keep the bath in balance, the ratio of anode to cathode area

being normally at least 1:1. With "High Speed" tin anodes it is claimed that this ratio may be reduced, and the preliminary high voltage needed to form the film on a normal anode can be dispensed with.

Radiation Pyrometer Measurements

ALTHOUGH developed as a radiation pyrometer for monitoring the surface temperature in an induction hardening process, an instrument produced by the Wembley Research Laboratories of The General Electric Company Limited has a number of applications. These include:—With probe: hardening and tempering by a progressive method; induction melting; furnace charge temperatures; temperature measurements where the source is obscured by intervening structures; temperature of liquids. Without probe: strip and sheet rolling; extrusion temperatures; flame temperatures.

The device, which consists of a thermopile specially constructed so as to give an electrical output substantially independent of ambient temperature over a wide range of source temperature, may be used with a radiation collecting probe, or with an aperture stop—or system of collimating stops—in the path of the incident radiation.

The pyrometer is not an absolute measuring instrument, and requires calibration in any particular application.

In operation, a target body is mounted inside a cavity in an aluminium block, and is almost completely enclosed. Because of its high thermal diffusivity and thick wall, the cavity may be considered at uniform temperature.

A narrow pencil of heat radiation is allowed to fall on the target through a small aperture in the cavity wall, so that the temperature of the target is raised above the temperature of the cavity. The device is normally stopped down so that the temperature difference is only a few degrees Centigrade. The steady temperature rise of the target above the cavity is then a measure of the amount of radiation absorbed by the target, and indirectly of the temperature of the source of radiation.

The temperature differential of the target with respect to the cavity, due to a given source of radiation, changes only slowly with the temperature of the cavity itself, provided the temperature of the source exceeds a few hundred degrees Centigrade. For example, a pyrometer of this form changes its target temperature differential less than 5 per cent for an ambient change from 15°C. to 50°C., when viewing a source at 300°C. Due to the sharply rising response of the pyrometer with source temperature, this represents an error in indicated source temperature of less than −6°C.

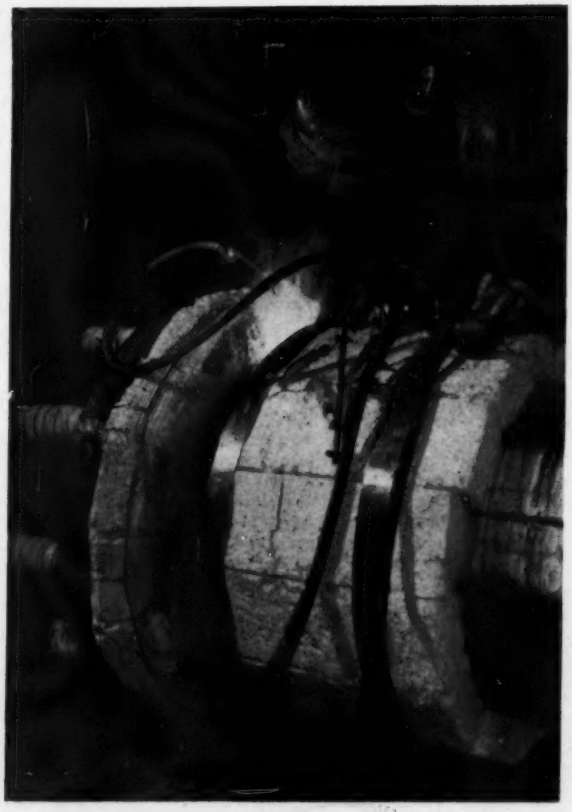
The output of the instrument naturally depends on the effective aperture of the pyrometer, and the disposition and surface condition of the source of radiation. With full aperture, the instrument responds to radiation from a cone of about 40° included angle, although the peak sensitivity occurs within a cone of 10° included angle.

Usually, the instrument is stopped down to give about 1 millivolt of output, which may be connected to a millivoltmeter or light-spot galvanometer. The response rate of the system in this case depends on the millivoltmeter, the response of the thermopile itself being very rapid. In fact, it is estimated that the thermal time constant of the pyrometer itself is of the order of 0·1 sec.

Heat-Treatment for Bulky Assemblies

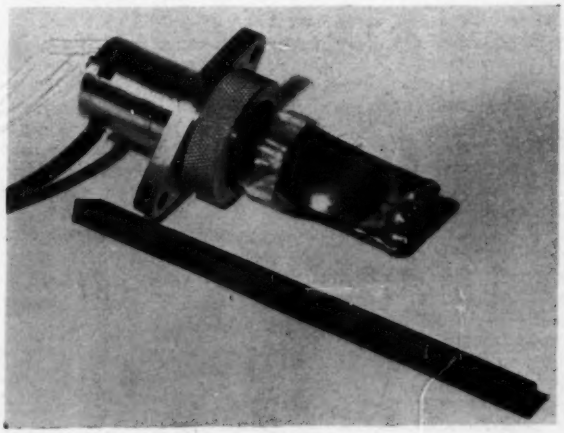
PRIMARILY designed for preheating and stress relieving of welds in large assemblies, Armoured Heaters—lengths of nickel-chrome resistance wires insulated to withstand working temperatures of 800°C.—have much wider potential usage, and other applications will readily present themselves. The resistance wires are covered overall with a flexible nickel alloy sheath, having an outside dia. of $\frac{1}{16}$ in., and the heaters, which can be applied to curved or flat surfaces, are placed about the area to be heated, connected to an electrical supply, and then covered with sections of high temperature-resistant lagging. The source of the electrical supply depends on the location of the job, but as Armoured Heaters operate at safe voltages of 50, 75 or 100, a welding transformer, generator, or a mains transformer can be used. The temperature is measured by a thermocouple or couples connected to a simple indicator, the readings from which enable the operator to control the temperature by on/off switching or voltage regulation. Other forms of temperature indicators, recorders and control gear can be used.

By the careful design of the heaters and their positioning with lagging, a large amount of heat can be dissipated in the required area; for example, an 18 ft. length at 75 V is rated at 3 kW. All heaters, which are a product of Electrothermal Engineering Ltd., are re-usable, and are available in standard lengths according to the rating required.



Right: Heat-treatment of welds being carried out with Armoured Heaters

Below : The head of the radiation pyrometer developed by the General Electric Company Limited



Atomic Progress

Irradiation Creep of Alpha Uranium

IN the Calder Hall reactors the uranium acts as a strut carrying the weight of fuel elements higher up in the channel. With a vertical arrangement of this type the creep behaviour of uranium is particularly important. In 1955 very little was known about the effects of irradiation apart from a report by Konobeevsky, Pravdyuk and Kutaitsev[1] to the effect that the creep of uranium is increased by a factor of 2. Since then, considerable attention has been devoted to this subject in this country and, because of its importance, two Papers[2,3] on this will be reviewed in this article before considering the irradiation behaviour of Calder fuel elements.

Creep and Irradiation Growth

There are many ways in which irradiation might exert an effect on the creep properties of uranium. Vacancies and interstitials created by neutron collisions might migrate to grain boundaries; internal stresses may help to produce plastic deformation or, after long irradiations, the concentration of new atoms created by fission may affect the mechanical properties and creep behaviour. Cottrell and Roberts[2] consider the case of a polycrystalline sample containing intergranular stresses large enough to bring its grains to the point of plastic yielding. Such an aggregate can deform under external stresses that are small compared with the yield point of a uniformly stressed sample. To many readers this will be familiar as a cause of deviations from Hooke's law at low stresses in polycrystalline solids. In these cases the internal stresses exist only as an initial condition, and soon become compensated for by differential plastic flow. Uranium is anisotropic and, under irradiation, growth occurs such that each crystal changes its shape progressively along certain crystallographic directions. Cottrell and Roberts predicted that the interaction of different grains undergoing growth in a polycrystalline aggregate would ensure the continuous regeneration of internal stresses, so that the uranium would not be able to oppose its full yield strength to applied stresses.

Irradiation growth is most rapid at 200°C., where the growth rate is about 4×10^{-19} sec^{-1} for a thermal neutron flux of 10^{12} cm^{-2} sec^{-1}. The growth rate falls slowly at lower temperatures and more quickly at higher temperatures, until it is very small at about 450°C. In the absence of an applied stress, the overall dimensions of a random polycrystal do not change under irradiation. The growth strains which occur in individual grains produce intergranular stresses which reach the yield strength in a time $t_m \simeq \sigma_y / E\dot{\varepsilon}_g$ where σ_y is the appropriate yield strength of the crystal, defined by Cottrell and Roberts as the smallest stress needed to operate those plastic modes that are capable of accommodating the growth strains; E is the appropriate elastic constant and $\dot{\varepsilon}_g$ the growth rate. Substituting typical values, t_m is shown to be of the order of 1 week. Up to the time t_m growth strains can be accommodated by elastic deformation, but thereafter the uranium must deform plastically.

The authors calculate the approximate creep rate by assuming that the application of a stress σ causes an elastic deformation of the order σ/E and a plastic deformation of the same order due to relaxations under the influences of internal and applied stresses. Before the overall plastic deformation can continue, the internal stresses have to build up again, and the time for this is of the order t_m. Hence

$$\dot{\varepsilon}_c \simeq \sigma/E\ t_m \simeq \sigma/\sigma_y\ \dot{\varepsilon}_g$$

Substitution of typical values gives an expected steady state creep rate of 10^{-10} sec^{-1} under an applied stress of 1,000 lb/in^2. The authors note two objections to this estimate. The first is that, because of the simple crystal symmetry of growth strains, they could be accommodated by a set of plastic deformation modes that contains fewer than the five independent modes needed to produce an arbitrary plastic deformation. In this case, the inactive modes might be capable of supporting the applied stress without yielding and the overall creep would stop after a deformation of the order σ/E. Cottrell and Roberts considered this unlikely, and thought the full number of deformation modes would be needed to accommodate the growth strains, with the result that creep would continue indefinitely during irradiation. The second objection arises from the possibility of more intense work-hardening of some grains as a result of the different amounts of plastic deformation. This could cause localized stresses to build up and balance the applied stress, thereby giving a transient creep effect. The authors do not think this differential work-hardening will be appreciable, and they consider that radiation hardening will be predominant.

In order to test their predictions, Cottrell and Roberts irradiated uranium wire springs. This form of specimen was chosen in order to obtain a large deflection from a small strain. The springs were fabricated from swaged and annealed uranium wire. A final heat-treatment was given which consisted of a beta quench and alpha anneal to produce a fine random grain structure in the wire. The springs were mounted vertically and sealed in quartz cylinders containing helium at atmospheric pressure. A total of four specimens was irradiated in B.E.P.O. in a neutron flux of about $1{\cdot}3\times10^{12}$ cm^{-2} sec^{-1} at a temperature of 100°C. (±10°C.). At weekly intervals the specimens were withdrawn from the reactor and measured. A fifth specimen was set up in the laboratory as a control.

The control specimen exhibited an extension of 0·3 mm. on raising its temperature to 100°C. and then remained constant over a period of several weeks, during which time several thermal cycles between 100°C. and 20°C. were made to simulate the thermal history of the in-pile specimens.

From three of the in-pile tests (the silica container broke with the fourth specimen) either no creep was observed initially or it was very small (for a period a little less than 1 week). The authors deduce from this $t_m = 6\ (\pm1)$ days, in agreement with the theoretical value. During the first three weeks, irradiation transient creep occurred, followed by steady-state creep. The observed creep rate of 1·16 elastic deflections per week confirmed the theoretical estimate, although the creep rate did not vary linearly with stress. A two-week interruption of the irradiation caused the creep curve to be displaced along the time axis by the same amount. During this interval in the pile at zero power the specimens continued to creep. When taken out of the pile after completion of the tests the deformation reversed. Continued creep after irradiation stops is to be expected, since the internal stresses persist until they are relaxed by creep. The reversal of creep is unexpected and the authors suggest that it may be related to the changes in elastic constants which are known to occur in uranium after irradiation.

Thus, in the temperature range at which irradiation growth occurs it is seen that irradiation causes creep under conditions of temperature and stress at which creep does not occur under normal conditions. Not all fuel elements in a nuclear power station will operate with the fuel in this range of temperature; some will be at higher temperatures in the alpha range, where thermal creep is important.

Irradiation and Thermal Creep

The second Paper,[3] by H. C. Rose, considers the effect of irradiation on the thermal creep of uranium at 450°C. In this work, the creep rates were of

(*Continued on page* 539)

Finishing Supplement

Tin-Nickel Plating for Instruments

LEADING makers in high precision industries, for example, watch and scientific instrument manufacturers, are now, according to *Tin and Its Uses*, choosing tin-nickel electroplate for their products.

The pinkish tinge of tin-nickel alloy electroplate makes it easily distinguishable from other plated finishes, such as silver and chromium, and also from aluminium and its alloys. It tones well with stainless steel. Chemically, the resistance of tin-nickel is outstanding, and it closely resembles the platinum metals in its nobility towards nitric acid. It is much harder than nickel and has about the same hardness as chromium, so it has excellent resistance to scratching and abrasion. It has a low coefficient of friction.

In watch-making, the properties of throwing power and resistance to corrosion are particularly important. The tin-nickel plating resists the corrosive and staining effect of sweat from the the fingers of watch-makers. It is difficult to avoid finger contacts with watch movement parts and consequent spoilage, but this non-staining finish prevents corrosion and finger-marking throughout the life of the watch. Secondly, tin-nickel "throws" successfully between closely set gear-teeth and into small pinion-bearing holes, where its anti-frictional properties are of special value.

The tin-nickel electroplate is applied to all the interior parts of the watch, so that surfaces which bear on or engage each other are protected from wear. In addition, the tin-nickel alloy electroplate has the property of retaining films of lubricating oil without being corroded by them even after prolonged contact.

Tin-nickel protects interiors of watches against corrosion due to condensation. An additional advantage of the alloy for this purpose is that either the bezel or the watch-case may, if desired, be made of stainless steel while the other part is plated with tin-nickel, without there being any noticeable colour contrast.

In an ordinary wrist watch there are between 50 and 100 pinions, cogwheels, pins, screws, levers, barrels, springs, pawls, and ratchet wheels. The smallest screws may indeed be far smaller than the heads of the smallest pins of the type used for stationery and, while the bulk of them are bigger than this, 10,000 may weigh less than 1 lb. In general, a selection of barrels ranging from a few cubic centimetres up to a litre suffices for much of the work, but a five-litre barrel may be preferable for watch-cases and frames.

The thickness of the tin-nickel coating which is plated on to such parts has, of course, to be very precisely controlled, and it is usual to apply coatings up to 0·0003 in. (0·0075 mm.) in thickness to the larger parts, while, for the smallest screws, as little as 0·00003 in. (0·00075 mm.) may be sufficient. Even in these exceptionally thin coatings, the tin-nickel deposit provides worth-while protection, and also the lubricating quality required. The fact that the finish can be applied to parts made of different metals, e.g. steel, copper and brass, makes it possible to have all the component parts of the same colour. Since tin-nickel plating tends to be bright as applied, some makers do not polish the parts either before, during, or after plating. Where it is desirable for the tin-nickel electroplate to be brilliantly polished, this is readily accomplished because the electroplate is fine-grained.

A number of firms making other high-class precision instruments, such as telescopes, drawing instruments and microscopes, have also adopted tin-nickel alloy as an electroplate.

The resistance of tin-nickel to finger-marking is a valuable feature in the case of drawing instruments. Handling in factory, warehouses and shops leaves no permanent stains on the instruments. Furthermore, owing to the ability of tin-nickel to retain its high lustre indefinitely, there is no risk that the finish of the instruments will deteriorate while in stock. The thickness of tin-nickel alloy applied to one brand of drawing instruments is usually about 0·0003 in. (0·0075 mm.). In its unpolished form, tin-nickel is also used for low-priced compasses for school use.

Tin-nickel electroplate is not an expensive finish, costs being closely comparable with those of nickel-chromium finishing, with the added advantage that the tin-nickel is plated in a single plating bath as compared with the two required for the separate operations of applying first nickel and then chromium.

RECENT DEVELOPMENTS PROMISE FUTURE IN DIFFICULT APPLICATIONS

Electrophoretic Coatings

By D. J. FISHLOCK

INTEREST in electrophoretic deposition appeared to have lapsed when it was discovered that chemical coagulants could achieve everything that electrophoresis had to offer for the deposition of rubber, and much more rapidly and cheaply to boot. Indeed, the practical applications of electrophoresis in any field were few, and mainly restricted to special protein separation and analytical techniques.

Recently, however, there has been a resurgence of interest in the U.S.A. in the possibility of depositing both metallic and non-metallic coatings on, in particular, materials which are notoriously difficult to coat by conventional techniques. Five years of research by one company, the Vitro Laboratories Division of Vitro Corp. of America, have yielded remarkable ranges of materials coated and materials deposited by high-voltage electrophoresis from non-aqueous liquids. These promise to extend considerably the scope of many structural metals, and such materials as graphite, ceramics, molybdenum, aluminium and stainless steel, particularly in respect of their corrosion, erosion and high temperature oxidation resistance and their suitability as bearings under exceptional stresses and under radiation.

The process appears somewhat involved, since it includes several stages, and details of the economics—except in so far as some of the applications are quite unique—are not yet available. The basic stages are:—(i) Pretreatment—degreasing and sand-blasting. (ii) Electrophoretic deposition of the metal, oxide, etc., at 100 V upwards. (iii) Hydrogen reduction (sometimes necessary). (iv) Hydrostatic pressing at 10 to 50 tons/in^2. (v) Sintering in controlled atmosphere.

Electrophoretic deposition is the result of particles, both metallic and otherwise, acquiring an electric charge when in colloidal suspension, and thus becoming attracted to their oppositely charged electrodes. The speed of deposition bears no relation to ionic charges or equivalent weights, and Faraday's Laws do not apply. The governing factors are the particle size and the applied potential, and also the particle concentration and charge, and

the inter-electrode spacing. Further, the speed of deposition is very much greater than those encountered in plating, while the deposit is extremely uniform on irregular surfaces. The latter is due to the effect of the deposit on the bath's resistance, thin points attracting a greater proportion of particles until uniformity is achieved. The power consumed is very low and, depending on the coating, several kilograms are deposited per amp. hr. at a rate of 20 to 40 mil/min.

Although mixtures are often deposited, usually a metal and an oxide, carbide, silicide (e.g. nickel and chromium carbide, or copper and molybdenum disulphide), provided the suspension is maintained uniform by agitation and by activators, uniformity of the deposit is assured, even with multi-constituent coatings. Again, the thickness can be accurately controlled once the rate for a given set of plating conditions and a given suspension have been determined empirically.

The preparation of the suspension is somewhat critical. Water, of course, decomposes into its constituent gases when electrolyzed, and these increase the porosity and reduce the cohesion of the coatings. Non-aqueous fluids, such as isopropyl alcohol and nitropropane, are therefore used. To these are added selected activators which perform the triple function of improving the stability of the suspensions, increasing the density and strength of the newly-formed coatings, and influencing the charge on the particle. This charge is believed to arise through the unbalanced forces extant at the particle-liquid interface, and the activator, presumably by absorption, induces the same polarity of charge on many particles which would otherwise differ; its precise nature is a characteristic of the activator. The activators also assist both cohesion and adhesion, probably by increasing the charge on each particle, which induces it to pack and bind more tightly. The particle size is also of importance, a range from 1 to 50μ being the optimum for dense coatings; below this there is a tendency for shrinking and cracking, while large particles lead to unstable suspensions and heterogeneous coatings.

The later stages in processing are concerned with the full development of the physical properties of the coating and its sound adhesion, the as-deposited coating being poorly cohesive.

By introducing a metallic binder into the coating much sounder deposits are secured. Two methods of achieving this have been evolved: one is to co-deposit the oxide of a metal such as nickel or iron and subsequently reduce this to the metal in a hydrogen furnace; this is followed by heating to a temperature sufficiently high to sinter the coating. The other, for use with materials which cannot be sintered, consists of electrodepositing metal on the porous coating surface. The deposition penetrates, due to the electro-osmotic effect caused by the potential drop across the porous "membrane," right through the coating, and gradually fills the voids. A nickel chloride solution has been found suitable. Another method of increasing the density is to apply a high hydrostatic pressure through a medium such as glycerine.

Thus far over 40 different combinations of metals and/or non-metals have been achieved on a wide variety of base-materials. Typical examples include the coating of steel with molybdenum to provide resistance to molten metals and also an improved bearing surface; the deposition of a stainless iron-nickel-chromium alloy on copper or steel for exceptional corrosion resistance; the coating of graphite with such materials as tantalum carbide to provide erosion and oxidation resistance; and the deposition of molybdenum disulphide-copper (75:25) and boron nitride-copper-nickel (35:30:35) coatings on stainless steel for lubrication under exceptional conditions of temperature, pressure and radiation.

So far as future developments are concerned, work is proceeding into a yet greater variety of coatings, with the atomic energy industry as the principal goal. Such applications as a chromium diffusion barrier coating on uranium dioxide fuel elements, coatings of zirconium and zirconium dioxide, new lubricating deposits and impervious carbide deposits on graphite are the primary targets.

Peelable Stop-Off Material

BUTYRATE peelable plastics, a product well known and long used in the protective coating field, is being used in a number of plating plants throughout the United States to save time and cut the cost of masking metal parts in preparing them for partial plating, and one firm has adopted it as a standard procedure. Previously, lacquer-type coatings which required a relatively long drying cycle were used. Moreover, such coatings were difficult to remove. Now, parts to be partially plated are simply dipped in the molten plastics and withdrawn a few moments later. The plastics coating solidifies within 60 sec., and is then quickly trimmed or peeled away from the areas to be plated. After plating, the remaining coating is stripped off, rinsed, and returned to the melt tank for re-use.

The ease with which butyrate peelable coating can be stripped off is shown by this aircraft wing control lever whose interior bearing surfaces have just been plated

The ease of removal and the fact that the coating can be re-used have enabled substantial reductions in both time and labour costs to be achieved on certain plating jobs as compared with the use of conventional lacquers.

The advantages of butyrate peelable plastics as a stop-off coating are illustrated by a recent two-step operation carried out by United Platers Inc., involving the selective plating of an aircraft wing control lever. Specifications called for the part to be completely cadmium-plated except for six bearing surfaces which were to be lead-plated. The problem was solved by plugging the bearing holes with the butyrate plastics composition prior to cadmium plating. Following the cadmium plating operation, the plugs were removed, and the entire part dipped into the molten plastics. The plastics which penetrated into the bearing holes was then trimmed away and the part immersed in the lead plating bath. Stripping away the coating at the conclusion of this cycle completed the operation.

Corrosion Properties of Titanium Alloys

CHEMICAL and galvanic properties of commercially-pure titanium (C 0·44; N_2 0·027; O_2 0·1; Fe 0·13; Mn 0·076; W 0·02 max.; Si 0·04 max.), a titanium-manganese alloy (8 Mn), a titanium-aluminium-tin alloy (5 Al, 2·5 Sn), two titanium-copper alloys (1 and 5 Cu) and two titanium-aluminium alloys (2 and 6 Al) have been reported by C. B. Kenahan and D. Schlain of the U.S. Bureau of Mines.

Tests were conducted in synthetic sea water (A.S.T.M. Standard), tap water, 1 per cent sodium hydroxide, 5 per cent ferric chloride, and 5 per cent ammonium sulphate solutions, various concentrations of sulphuric and hydrochloric acids, and 1 per cent oxalic acid. All tests were carried out at 35° or 60°C., with a flow of air or helium. Dissimilar metals involved in galvanic-couples experiments were aluminium, magnesium, and stainless steel. Electrode-potential measurements on single (uncoupled) specimens were also measured.

Chemical and galvanic corrosion properties of the titanium-base alloys are quite similar to those of unalloyed titanium.

Commercially-pure titanium and the titanium alloys are completely resistant to chemical corrosion in synthetic sea water, tap water, 1 per cent sodium hydroxide, 5 per cent ferric chloride, and 5 per cent ammonium sulphate solutions with a flow of air at 35° and 60°C. In contact with stainless steel, aluminium or magnesium at 35°C., the titanium metals are immune to galvanic attack in air-saturated or air-free synthetic sea water and tap water.

The titanium-base alloys are similar to titanium in their resistance to corrosion in 1, 3 and 5 per cent sulphuric acid solutions at 35°C. with a flow of air, but at 60°C., commercially-pure titanium is superior to all the titanium alloys except those containing copper. The copper alloys exhibit better corrosion characteristics than titanium in these media. They also show better corrosion qualities than titanium in 5, 10, and 50 per cent sulphuric acid solutions with a flow of air; however, both titanium and the titanium-copper alloys corrode rapidly in concentrated sulphuric acid.

Commercially-pure titanium resists chemical attack better than the titanium-base alloys in 4, 10, and 20 per cent hydrochloric acid solutions.

All the titanium metals corrode rapidly in 1 per cent oxalic acid solution at 60°C. with a flow of air, and at 35°C. in an air-free solution; however, the titanium-aluminium-tin alloy and 6 per cent aluminium alloy are not as resistant as the other titanium metals at 35°C. in a solution saturated with air.

In air-free 0·1*N* sulphuric acid solution, the titanium metals corrode slowly by galvanic action after an initial period of immersion. Contact with stainless steel in 1, 2, and 4*N* sulphuric acid solutions with a flow of air causes little or no galvanic corrosion of the titanium metals; in the absence of air, rather severe galvanic corrosion of the titanium alloys sometimes occurs, whereas commercially-pure titanium is affected only slightly.

When coupled with aluminium (99 per cent min.) in air-aerated 0·1*N* sulphuric acid, or in 1 per cent oxalic acid, the titanium metals undergo cathodic corrosion. Coupling with stainless steel in sulphuric acid decreases the normal corrosion rate of the titanium metals.

Contact with the various titanium metals causes little or no galvanic corrosion of aluminium in synthetic sea water. Magnesium is heavily attacked by galvanic action when coupled with titanium or the titanium-base alloys in tap water with a flow of air.

Aluminium corrodes quite rapidly as a result of coupling with the titanium metals in 0·1*N* sulphuric acid with a supply of air, but in the absence of air, aluminium is the anodic member of the couple only during a period immediately after immersion. Stainless steels generally resist galvanic corrosion when coupled with the titanium metals.

In a 1 per cent oxalic acid solution, aluminium is anodic only during an initial period after immersion, following which the titanium metal becomes anodic.

Contraction Stresses

SINCE the preparation of the Paper entitled "Contraction Stresses in Sprayed Metal Deposits," by W. E. Stanton, which appeared in the issue of METAL INDUSTRY for 19 December, 1958, pp. 509-511, further investigations have been carried out by the author to determine the fibre stresses in a wider range of materials. The results of this work are appended in the Table given below.

Material	Deflection (in.)	Weight Equivalents (Transverse Load) (lb.)	Max. Fibre Stress (lb./in.²)
90/10 Brass	0·032	0·39	3,350
Gunmetal	0·042	0·50	4,300
70/30 Brass	0·055	0·63	5,400
Nickel	0·063	0·77	6,600

Atomic Progress—*continued from page 536*

the order of 10^{-4}/hr., compared with 10^{-7}/hr. in Cottrell's spring experiment.

The method employed by Rose was to strain small specimens, thereby reducing temperature gradients under irradiation, under a compressive stress applied by dead weight loading. The creep properties of each specimen were determined in the pile irradiation assembly before each in-pile run, and the results compared with the in-pile data. The tests were restricted to short duration, due to variations in the reactor flux; two creep curves were obtained for periods of about 160 hr. A strain of 4·3 per cent occurred during periods totalling 170 hr. when measurements could not be obtained because of pile flux and temperature fluctuations. This strain corresponds to a mean strain rate of 25×10^{-5}/hr. Such a rate is far higher than the observed secondary creep rate ($6{\cdot}6 \times 10^{-5}$/hr.) and is about the same as the initial induced primary creep. The effect is of considerable importance since the total creep strain is about treble that expected if secondary creep rates only were involved. The effect may be due to irradiation or thermal cycling, although current views are that the latter is likely to be the most important factor. In the short time of the test there appeared to be no change in the secondary creep rate as a result of irradiation.

A considerable amount of detail is given in this Paper on the experimental technique, and reference to it will give an insight into the difficulties of doing closely controlled experiments of this type in a reactor.

The implications of these effects on Calder and Civil fuel elements will be discussed in the next article.

References

1 S. T. Konobeevsky, N. F. Pravdyuk and V. I. Kutaitsey; Geneva Conference on Atomic Energy, p. 681 (1955).

2 A. C. Roberts and A. H. Cottrell; *Phil. Mag.*, August, 1956, Series 8, **1** (8), 711.

3 H. C. Rose; *J. Inst. Metals*, 1957-58, **86**, 122.

Industrial News *Home and Overseas*

Stelvetite Exhibition

An exhibition devoted entirely to the fabrication and applications of Stelvetite, the new plastics-coated steel sheet, is to be held at the Royal Festival Hall, London, from January 13 to 16 next by the manufacturers, **John Summers and Sons Ltd.** There will be a series of demonstrations, including spot welding (which can be done without damage to the P.V.C. coating), high frequency welding, lock forming, printing and drum sealing.

Stelvetite in all its available colours and gauges will be shown with a large selection of the items now being produced in the material, such as office furniture and machines, chemical equipment, refrigerators, domestic water heaters, and clocks. Admission to the exhibition will be by invitation only except on the last day (Friday), when it will be open to persons holding tickets, which can be obtained upon application to the company at St. Ermin's, Caxton Street, London, S.W.1.

London Offices

On Tuesday of last week **The British American Metals Company** held a housewarming at their new offices at Bucklersbury House, London, E.C. This concern is the sales representative of the Anaconda Export Company and Anaconda-Jurden Associates Inc. of New York.

An Order from Italy

It has been announced by **The Incandescent Heat Company Ltd.** that it has received an important order for an annular hearth rotary furnace, to be installed in Northern Italy. The furnace will be fired by the Incandescent Equiverse system, using natural gas. By this method, oxidation is completely eliminated when heating steel in a direct-fired furnace. The process can be used with batch or continuous furnaces, for extrusion, rolling, forging, and any other heating process up to 1,320°C. Plants using this system are already in operation in Great Britain, France, Germany, and the United States of America.

The furnace, which has a mean diameter of 6 m., will be used for heating alloy steel blanks for piercing in a vertical press, the first operation in the production of high pressure liquefied petroleum gas bottles. High-speed fully automatic manipulators, capable of handling up to 42 blanks/hr., are to be supplied with the plant. The value of the furnace and its auxiliary equipment will be about £50,000 when installed.

Heat Transfer

Some 12,000 references to published Papers and books on all aspects of heat transfer and related subjects are included in the latest edition of the M.E.R.L. *Heat Bibliography*. It contains references to heat transfer by conduction, convection and radiation; boiling, condensation and evaporation; heat exchangers of various kinds; and physical properties such as entropy, specific heats, thermal conductivity, and viscosity.

The references were obtained from original publications and abstract journals; all titles noted in M.E.R.L. during 1955 and 1956 which appeared to be relevant are listed. The titles are printed under a simple subject classification which avoids cross-referencing. Copies of *Heat Bibliography* 1955-56 are available from the Mechanical Engineering Research Laboratory, East Kilbride, Glasgow.

An Order from Belgium

As agents for **Marston Excelsior Ltd.**, of Wolverhampton, I.C.I. (Belgium) S.A. have obtained an order worth just over £100,000 for aluminium piping in connection with the experimental water-cooled reactor BR.2, now in course of erection at the nuclear research centre at Mol, in North Belgium, for Centre d'Etudes Nucleaires. Both firms are subsidiaries of Imperial Chemical Industries Ltd.

This is believed to be the first large order related to nuclear energy to be obtained by a British firm in Belgium, and is also the first such order to be placed with I.C.I. by a nuclear organization outside the United Kingdom. It comprises piping and fittings in aluminium alloy, up to 30 in. diameter, to connect the reactor shell to the heat exchangers and the exchangers to the cooling pond.

BR.2 is an advanced type of materials and engineering test reactor, using uranium enriched to 90 per cent U235 as fuel, with metallic beryllium as the moderator. At full output of 50 mW the epithermal flux will be $2{\cdot}4\times10^{15}$ neutrons/cm^2/sec., and the thermal flux $6{\cdot}2\times10^{14}$. Criticality will be obtained with approximately 4 kg. of fuel. Heat will not be recovered, but will be removed from the reactor by demineralized natural (not heavy) water circulated at 2,270 m^3/hr.

Scientific Instrument

Now available through **Winston Electronics Ltd.** is the Beckman/Berkeley University Eput meter, type 7360, which has a wide variety of uses in universities, industrial research and development laboratories, and in industry generally.

Applications include counting, time interval measurement, events-per-unit-time measurement, pressure, flow measurement, timing relay, shutter action, tachometry, telemetering, events counting, ratio measurement, high and low frequency measurement, stability checking, secondary frequency standardization, phase measurement, precise event timing, relay and switch timing, timing generator, ballistic, viscosity, and elasticity measurement.

Vacuum Furnace Alliance

It has been announced by **The General Electric Company Limited** that an agreement has been reached with Vacuum Industrial Applications Ltd., of Wishaw, Scotland, which combines the considerable resources of the two companies in the vacuum heating field for the development of vacuum heating techniques, and the design and manufacture of complete vacuum furnace installations.

Both companies have considerable experience in this field. Vacuum Industrial Applications Ltd., who specialize in industrial vacuum equipment, including pumps, gauges, valves and pipelines, have themselves designed vacuum furnaces using induction heating units, including dual purpose equipments with alternative resistance heating units. The G.E.C. are, of course, well known in the field of electric furnaces, and are specialists in the development of controlled atmosphere processes.

Acting jointly, the companies command excellent facilities for research, design and manufacture, and are well equipped to meet demands for complete installations for vacuum melting, sintering, brazing, degassing, stream degassing, and general heat-treatments. Under the terms of the agreement enquiries will be handled by the G.E.C.

A German Subsidiary

A member of the Cleveland Group, **Simmonds Aerocessories Limited** announce the formation in Germany of Deutsche Firth Cleveland G.m.b.H. as a subsidiary company. The new company has taken over extensive offices at Neckarauerstrasse 245-53, Mannheim.

The new company has been set up in anticipation of the establishment of the Common Market and the Free Trade Area, and it will undertake the marketing in Germany of most of the products of Simmonds Aerocessories Limited, as well as those made by Simmonds British subsidiary — Firth Cleveland Instruments Limited.

Mr. A. A. Puth has been appointed general manager of Deutsche Firth Cleveland G.m.b.H. He is assisted by Mr. H. Seiler as Surform sales manager. All the products handled by the new company will continue to be made in Treforest, Glamorganshire.

Water Meters to Iran

A new order recently placed with **George Kent Ltd.** for a further 32,000 water meters—with the option to extend it to 38,400—brings to over £300,000 the value of Kent meters already installed or on order by the Teheran Water Authority since 1956.

The policy of Teheran being to meter every supply of water (to both private and commercial consumers), and the financial and sociological success of this policy being associated with the accuracy of the meters used, upon which all revenue depends, the merit of this repeat large order is all the more to be appreciated. This business has been the subject of competition from meter manufacturers of many countries.

Process Instrumentation

A one-day Symposium on "Instrumentation in the Process Industries" was recently organized by **Sunvic Controls Limited.** It was attended by more than fifty directors and technical/commercial executives from other companies in the A.E.I. group, as well as from chemical and petroleum companies, and electricity authorities. Chairman of the Symposium was Mr. N. R. Davis, managing director of the company.

Five Papers were delivered by Sunvic executives. They covered techniques and applications of automatic control and instrumentation as at present applied to processes involving continuous flow production, especially oil, chemicals and

nuclear power, and also surveyed future development and trends. Considerable emphasis was placed on data processing and automatic computation, particularly in relation to possible applications in fully automatic plant control. The commercial implications of an increasingly important role for instrumentation were also considered.

In addition to hearing these Papers and discussing their content, visitors had an opportunity to inspect current Sunvic production of potentrometric recorders, data logging units, reactor instrumentation, and naval control panels, as well as watching a complete data handling unit demonstrated. They also visited the Sunvic mobile exhibition vehicle to see demonstrations of pneumatic instruments.

New Contract for A.E.I.

Following the recent successful commissioning, on schedule, of a new 8,000 h.p. twin-motor reversing plate-finishing mill at their Appleby steelworks, the Appleby-Frodingham Steel Co., Scunthorpe, has awarded another important contract to the newly-formed **A.E.I. Heavy Plant Division** at Trafford Park.

The contract calls for the supply, delivery and erection of the electrical main drive equipment for a new 12 ft. twin-motor reversing plate-roughing mill, which will replace an existing mill and which will operate in conjunction with the recently commissioned finishing mill. It will roll slabs weighing up to 25,000 lb. down to dimensions suitable for finish rolling in the finishing mill, the two mills being situated in line to facilitate ease of transfer and to reduce handling size.

In addition to supplying the above equipment with its control gear, the Division will also act as main contractors for the cable installation and the ventilation equipment necessary to provide the cooling air to the machines.

Courses for Buyers

Short courses for buyers in industry and public authorities have been organized by the Purchasing Officers' Association. The first course will deal with the "Industrial Purchasing Officer's Role in Constructional and Engineering Contracts." It will be a non-residential course from Tuesday to Thursday, February 17-19, 1959, at Stationers' Hall, Stationers' Court, Ludgate Hill, London, E.C.4. Course fee 10½ guineas. The course will cover the role of the purchasing officer, with relation to those of the architect, the civil engineer, the quantity surveyor, and the engineer in constructional and engineering contracts, together with the subjects of contract conditions, claims, and the purchase of engineering supplies. There will also be case study groups and plenary discussions.

The second course will be an advanced purchasing course. It is a residential course for chief buyers, from April 13-18, 1959, at Christ Church, Oxford. Inclusive fee £25. Again conducted by Professor Howard T. Lewis, of Harvard University, the course will cover departmental relations, inventory control and data processing, value analysis programmes, and operations research, and will include syndicate and plenary case study discussions. In addition, there will be addresses by Mr. Roy Harrod, M.A., on "The Current Economic Situation," and by Mr. J. H. M. Pinder, managing editor of the Economist Intelligence Unit, on "Britain, Europe and the Commonwealth."

Full particulars and application forms are obtainable from:—The Secretary, Purchasing Officers' Association, Wardrobe Court, 146a Queen Victoria Street, London, E.C.4.

Wire Brushes

An announcement from the British Standards Institution recalls that a new British Standard (B.S.2939) was published in January 1958, primarily to assist local authorities and hospitals to procure good quality brushes in a comprehensive range of sizes. It is, however, pointed out that several manufacturers in the industry are still receiving orders referring to the old War Office specification TG 26.

This has, in fact, been superseded by B.S.2939, which also includes specifications for many brushes not previously standardized. It would be helpful to all concerned if purchasing officers would familiarize themselves with the terms of the new standard and use it as a reference point when they are in the market for new brushes.

An Agreement

An announcement has been made by **R. Cruickshank Ltd.**, of Birmingham, to the effect that they have reached an agreement with the Pennsalt International Corporation S.A., under which Cruickshank Ltd. is granted exclusive licence for the manufacture and sale in the U.K. of a wide range of Pennsalt products for the metal industries, also for the sale of these products in certain overseas countries.

By agreement with the Pennsalt Chemical Corporation, U.S.A. licence to use the Pennsalt trade marks is also granted, thus ensuring the high standard of these products.

National Lending Library

To provide for the new National Lending Library for Science and Technology, the Department of Scientific and Industrial Research will take over the former Royal Ordnance factory at Thorp Arch, near Boston Spa, Yorks. Present proposals indicate that the library will begin operation in 1961 and become fully operational during the following year. Existing large single-storey buildings will be converted into offices and book stores, and the site provides adequate room for expansion in the future.

The new library—the nucleus of which already exists in the D.S.I.R. lending library now at Chester Terrace, Regents Park, London—will cover all subjects in science and technology, except for some fields of medicine. It will take over the responsibility for the lending service now provided by the Science Museum Library, which will in future concentrate on serving the needs of the enlarged Imperial College of Science and Technology.

News from Scotland

It is reported that **William Jacks and Company Limited** have acquired the patents and assets of the Tubes Division of John S. Thomson and Sons, Greenock, and plan a new factory at Dalrymple Street, Greenock, for manufacture of glass fibre pipes and tubes, under the name Thomson Tubes. John S. Thomson has been developing new mechanical manufacturing methods, resulting in tubes and pipes of maximum strength, non-porous, and suitable for many purposes in the engineering and transmission field.

North British Electric Welding Co. have completed a cable chain with a diameter link of 4⅛ in., which is stated to be the largest yet made in Scotland. Each link of the current chain weighs 2 cwt. Started in 1940, North British have carried out a considerable amount of cable chain production, and have current orders on hand for super tanker cable chain of 3⅝ in. diameter.

James Scott and Company (Electrical Engineers) Limited have located a new electronics division factory at Carntyne Industrial Estate, Glasgow, where they are producing batch runs of special equipment for a large number of industries. The new plant incorporates development laboratories, a tool department, modern machine shop and press shop, assembly sections, and other units.

A Science Exhibition

In March next year, the Royal Society of South Africa proposes to hold a science exhibition in the Old Drill Hall in central Cape Town. There will be three main sections—(1) pure science, (2) science in its application to industry and commerce, and (3) scientific equipment. The charge to exhibitors will be a nominal fee of 3s. ft^2 to cover expenses. The total floor space available is stated to be 10,500 ft^2 and, therefore, there will only be room for small-scale exhibits. An individual exhibit should not exceed 60 ft^2.

The U.K. Information Officer at Cape Town plans to provide a supporting display of photographs, and possibly other material, on U.K. scientific achievements. United Kingdom firms wishing to take part in this exhibition should get in touch with the organizing secretary Dr. Donald Singer, South African Museum, P.O. Box 61, Cape Town, by the middle of January.

A Boat Exhibition

Opening on Wednesday next, December 31, the fifth **National Boat Show** brings a wide range of boats and boat equipment before the public. Some 250 exhibitors will be showing over 300 craft of various kinds, from collapsible prams to ocean racers, built from a variety of materials — mahogany, teak, plywood, fibreglass, and, of course, aluminium. The show includes extensive ranges of ship's chandlery, a field in which copper, brass, bronze, aluminium and aluminium-bronze are widely used. The show, which is at Olympia, remains open until January 10 next.

Obituary

Mr. W. E. Wright

IT is with regret that we record the death of Mr. William Elkington Wright, F.C.S., a director of The Pyrene Company Limited until his retirement in 1957. Mr. Wright was responsible, primarily, for the Metal Finishing Division of the organization. He joined The Pyrene Company Limited nearly 30 years ago, and pioneered in this country the use of phosphate coating processes on a production scale.

Prof. W. Wardlaw

WE also regret to announce the death of Professor William Wardlaw, C.B.E., D.Sc., F.R.I.C., at the age of 66. He was formerly Professor of Physical Chemistry at Birkbeck College, London University, and prior to that spent nearly 20 years at Birmingham University, where he was senior lecturer in inorganic chemistry. He was joint secretary, War Cabinet Scientific Committee, from 1941-1945.

Metal Market News

THE week started with news of the November world statistics of copper, published by the Copper Institute, the details being given in short tons of 2,000 lb. It had been estimated that there would be a fall of at least 50,000 tons in the stocks, but in the event the actual figure proved to be only about 32,500 tons, which is, after all, not an insignificant quantity when considered in conjunction with the drop of 106,000 tons at the end of October. The details are as follows: inside the United States, production of crude copper was 110,463 tons, against 112,079 in October, and of refined 128,048 tons, against 113,288. Deliveries at 131,288 tons were about 10,500 tons up, while stocks at November 30 fell from 128,490 tons at October 31 to 93,956 tons at the end of last month. Outside the United States the production of crude copper was 132,314 tons, against 113,472 tons, while the output of refined rose from 78,911 tons in October to 102,061 tons. Deliveries of refined copper at 129,809 tons were heavily down compared with the October figure of 171,827 tons, and stocks of refined copper increased by 2,000 tons to 143,178. The drop of 2,000 tons in deliveries to consumers, of course, reflects the almost entire absence of Rhodesian supplies during November. Other statistical information related to the L.M.E. stocks of standard copper, which were announced as 50 tons down at 5,946 tons, while tin, rather surprisingly, showed a reduction in Metal Exchange stocks of 690 tons to 16,383 tons.

Apparently the market took a poor view of the fact that stocks outside the United States rose by about 2,000 tons at November 30, but it would seem that the overall picture is what matters and, as already mentioned, that amounted to a drop of around 32,500 tons. However, Monday saw buyers on the market rather reluctant, and at £218 10s. 0d. for cash with a "back" of 5s., the prompt position was nearly £3 down on the previous Friday afternoon. Cash was firmer in the afternoon and the backwardation widened, with three months easing to £218. The Kerb was 10s. higher. Zinc and lead were rather firmer. Not surprisingly, business has been quiet and last week was already showing the impact of the Christmas holidays. Business in scrap has been reported rather poor of late, and this is probably due to the fact that buyers wish to limit their intake just before the shut-down at Christmas. On the whole, business in old metals this year has been fairly brisk, and consumption has been maintained at a steady rate. There has been a tendency for margins to move in favour of buyers, and during the past few months secondary copper of all kinds has been relatively cheap. Very considerable quantities of old metals have been put on the disposal list by the Ministry of Supply and other bodies, and sold by tender to the users.

As the year end approaches we may reflect on the fact that the so-called c.i.f. European electro price has been running since the beginning of February, and during that time has ruled for the most part above the L.M.E. settlement quotation. So far as can be seen, this weekly average price has not served any special purpose, and has not been employed as the pricing medium for any transactions. However, it could happen in the New Year that this will be done, but obviously any manufacturers buying on the basis of this average price and selling at a figure based on the L.M.E. settlement quotation would be in danger of being out of pocket on the transaction.

Birmingham

At the recent monthly meeting of the Midland Regional Board for Industry, Major C. R. Dibben, the chairman, said that while there was no complacency about trade and unemployment locally, there was now confidence that a general upward trend could be expected. Many industries in the consumer durable goods field were experiencing a strong upsurge in demand. But there was still particular concern over the cycle, machine tool, and carriage and wagon industries, which seemed unlikely to participate in the general improvements. In the New Year, Mr. A. N. Halls, Midland Regional Controller of the Board of Trade, will open a campaign to persuade Birmingham industry to open factories in areas where unemployment is high.

Another foundry in the Midlands has been obliged to reduce its labour force owing to lack of orders. It is hoped that this is only a temporary measure, but lack of orders for castings has made the step inevitable. Iron and steel producers are looking to the New Year to bring some revival of buying. At present there is a good deal of short-time working, and consumers are buying from hand to mouth instead of making long-term contracts. Some firms will be stocktaking next week following the Christmas break. Movement of both raw and finished material will be at a minimum. In many cases stocks are higher than they have been for several years.

New York

Latest available information from the American market was that copper was steady and quiet. After early easiness, futures rallied on covering in modest dealings. Custom smelters and producers indicated light sales. A leading producer source said that whereas sources abroad were looking for improved sentiment in the second quarter of 1959, United States copper experts expected the first quarter of the New Year to be better than the second quarter.

A Dow Chemical Company executive has predicted that magnesium will give aluminium stiffer competition in the not-too-distant future. Mr. Calvin Campbell, who is a vice-president of Dow, told the Washington Society of Investment Analysts that when magnesium attains a competitive position after casting problems have been solved, the automotive industry will take up the entire production of the Freeport plant. This is the Dow plant which has been set up to extract magnesium from sea water.

Zurich

The November improvement in Swiss non-ferrous metal business proved short-lived, and domestic consumers for some time have again been showing marked reluctance to commit themselves in view of the uncertain international trends. The situation has been bedevilled by a number of other depressing factors — the Free Trade Area deadlock, rumours of sterling convertibility, uncertainty on the timing of the introduction of the new Swiss customs tariffs.

Australia

News from Canberra is that Senator William Spooner, Australian Minister for National Development, has stated that the present world surplus of lead and zinc will continue for some time. He said Australian lead production in the current year was likely to be in the region of 310,000 tons, which was below the 1957 record. Reductions at Broken Hill, and losses from the closure of some small mines were offset by the expansion at Mount Isa, in north-western Queensland.

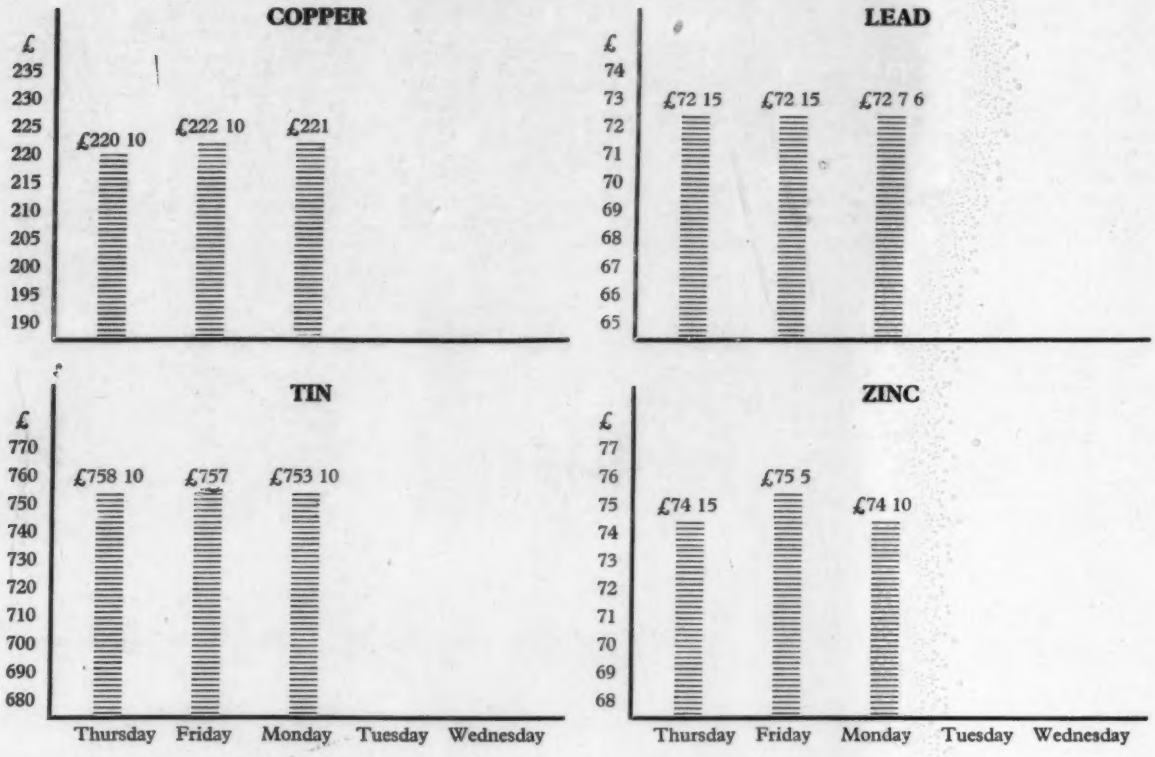
Senator Spooner declared that, if U.S. quota restrictions continued, they would mean a cut of about 50 per cent of Australian exports to the U.S. in 1959, compared with 1957.

India

News from India is to the effect that the Government of India have announced their decisions on a number of reports made by the Tariff Commission. The Government accepted, *inter alia*, the recommendation that protection to the aluminium industry should be continued for a further period of two years, till December 31, 1960, and the existing rate of duty of 35 per cent *ad valorem* should be maintained on (1) aluminium in any crude form, including ingots, bars, blocks, etc.; (2) aluminium manufactures—plates, sheets, circles, strips, and foil, including foil in any form or size, ordinarily used as parts and fittings of tea chests.

METAL PRICE CHANGES

LONDON METAL EXCHANGE, Thursday 18 December 1958 to Monday 22 December 1958



OVERSEAS PRICES

Latest available quotations for non-ferrous metals with approximate sterling equivalents based on current exchange rates

	Belgium fr/kg ≏ £/ton		Canada c/lb ≏ £/ton		France fr/kg ≏ £/ton		Italy lire/kg ≏ £/ton		Switzerland fr/kg ≏ £/ton		United States c/lb ≏ £/ton	
Aluminium			22.50	185 17 6	210	182 15	375	217 10	2.50	209 0	26.80	214 10
Antimony 99.0					195	169 12 6	445	256 2 6			29.00	232 0
Cadmium					1,500	1,305 0					145.00	1,160 0
Copper												
Crude												
Wire bars 99.9							435	252 7 6				
Electrolytic	30.75	224 15	28.00	231 5	268	233 2 6			2.95	246 12 6	29.00	232 0
Lead			11.75	97 0	115	100 0	176	102 0	.90	75 5	13.00	104 0
Magnesium												
Nickel			70.00	578 5	900	783 0 0	1,300	754 0	7.50	627 2 6	74.00	592 0
Tin	106.75	780 7 6			933	811 15	1,460	846 17 6	9.00	752 10	99.00	792 0
Zinc												
Prime western			11.50	95 0 0							11.50	92 0
High grade 99.95			12.10	100 0 0								
High grade 99.99			12.50	103 5 0								
Thermic					107.12	93 2 6						
Electrolytic					115.12	100 2 6	175	101 10	.91	76 0	12.75	102 0

NON-FERROUS METAL PRICES

(All prices quoted are those available at 2 p.m. 22/12/58)

PRIMARY METALS

		£	s.	d.
Aluminium Ingots	ton	180	0	0
Antimony 99·6%	„	197	0	0
Antimony Metal 99%	„	190	0	0
Antimony Oxide	„	180	0	0
Antimony Sulphide Lump	„	190	0	0
Antimony Sulphide Black Powder	„	205	0	0
Arsenic	„	400	0	0
Bismuth 99·95%	lb.		16	0
Cadmium 99·9%	„		9	6
Calcium	„	2	0	0
Cerium 99%	„	16	0	0
Chromium	„		6	11
Cobalt	„		16	0
Columbite	per unit		—	
Copper H.C. Electro	ton	221	0	0½
Fire Refined 99·70%	„	220	0	0
Fire Refined 99·50%	„	219	0	0
Copper Sulphate	„	74	0	0
Germanium	grm.		—	
Gold	oz.	12	10	2½
Indium	„		10	0
Iridium	„	20	0	0
Lanthanum	grm.		15	0
Lead English	ton	72	7	6
Magnesium Ingots	lb.		2	5½
Notched Bar	„		2	10½
Powder Grade 4	„		6	3
Alloy Ingot, A8 or AZ91	„		2	8
Manganese Metal	ton	290	0	0
Mercury	flask	74	0	0
Molybdenum	lb.	1	10	0
Nickel	ton	600	0	0
F. Shot	lb.		5	5
F. Ingot	„		5	6
Osmium	oz.		nom.	
Osmiridium	„		nom.	
Palladium	„	5	15	0
Platinum	„	19	10	0
Rhodium	„	40	0	0
Ruthenium	„	15	0	0
Selenium	lb.		nom.	
Silicon 98%	ton		nom.	
Silver Spot Bars	oz.		6	3⅞
Tellurium	lb.		15	0
Tin	ton	753	10	0
*Zinc				
Electrolytic	ton		—	
Min 99·99%	„		—	
Virgin Min 98%	„	73	0	7½
Dust 95/97%	„	109	0	0
Dust 98/99%	„	115	0	0
Granulated 99+%	„	98	0	7½
Granulated 99·99+%	„	112	12	6

Duty and Carriage to customers' works for buyers' account.

INGOT METALS

Aluminium Alloy (Virgin)		£	s.	d.
B.S. 1490 L.M.5	ton	210	0	0
B.S. 1490 L.M.6	„	202	0	0
B.S. 1490 L.M.7	„	216	0	0
B.S. 1490 L.M.8	„	203	0	0
B.S. 1490 L.M.9	„	203	0	0
B.S. 1490 L.M.10	„	221	0	0
B.S. 1490 L.M.11	„	215	0	0
B.S. 1490 L.M.12	„	223	0	0
B.S. 1490 L.M.13	„	216	0	0
B.S. 1490 L.M.14	„	224	0	0
B.S. 1490 L.M.15	„	210	0	0
B.S. 1490 L.M.16	„	206	0	0
B.S. 1490 L.M.18	„	203	0	0
B.S. 1490 L.M.22	„	210	0	0

		£	s.	d.
†Aluminium Alloys (Secondary)				
B.S. 1490 L.M.1	ton	142	10	0
B.S. 1490 L.M.2	„	152	0	0
B.S. 1490 L.M.4	„	169	0	0
B.S. 1490 L.M.6	„	186	0	0

†Average selling prices for mid October

*Aluminium Bronze				
BSS 1400 AB.1	ton	220	0	0
BSS 1400 AB.2	„		—	
*Brass				
BSS 1400-B3 65/35	„	142	0	0
BSS 249	„		—	
BSS 1400-B6 85/15	„	190	0	0
*Gunmetal				
R.C.H. 3/4% ton	„		—	
(85/5/5/5)	„	177	0	0
(86/7/5/2)	„	186	0	0
(88/10/2/1)	„	236	0	0
(88/10/2/½)	„	246	0	0
Manganese Bronze				
BSS 1400 HTB1	„	182	0	0
BSS 1400 HTB2	„		—	
BSS 1400 HTB3	„		—	
Nickel Silver				
Casting Quality 12%	„		nom.	
„ „ 16%	„		nom.	
„ „ 18%	„		nom.	
*Phosphor Bronze				
B.S. 1400 P.B.1 (A.I.D. released)	„		—	
B.S. 1400 L.P.B.1	„	202	0	0
Phosphor Copper				
10%	„	238	0	0
15%	„	241	10	0

Average prices for the last week-end.

Phosphor Tin				
5%	ton		—	
Silicon Bronze				
BSS 1400-SB1	„		—	
Solder, soft, BSS 219				
Grade C Tinmans	„	355	6	0
Grade D Plumbers	„	287	0	0
Grade M	„	389	6	0
Solder, Brazing, BSS 1845				
Type 8 (Granulated)	lb.		—	
Type 9	„		—	
Zinc Alloys				
Mazak III	ton	105	17	6
Mazak V	„	109	17	6
Kayem	„	115	17	6
Kayem II	„	121	17	6
Sodium-Zinc	lb.		2	6

SEMI-FABRICATED PRODUCTS

Prices of all semi-fabricated products vary according to dimensions and quantities. The following are the basis prices for certain specific products.

Aluminium			£	s.	d.
Sheet	10	S.W.G. lb.		2	8½
Sheet	18	S.W.G. „		2	10½
Sheet	24	S.W.G. „		3	1½
Strip	10	S.W.G. „		2	8½
Strip	18	S.W.G. „		2	9½
Strip	24	S.W.G. „		2	11
Circles	22	S.W.G. „		3	2½
Circles	18	S.W.G. „		3	1½
Circles	12	S.W.G. „		3	0½
Plate as rolled		„		2	8
Sections		„		3	2
Wire 10 S.W.G.		„		2	11½
Tubes 1 in. o.d. 16 S.W.G.		„		4	1

			£	s.	d
Aluminium Alloys					
BS1470. HS10W.		lb.			
Sheet	10	S.W.G. „		3	1
Sheet	18	S.W.G. „		3	3½
Sheet	24	S.W.G. „		3	11
Strip	10	S.W.G. „		3	1
Strip	18	S.W.G. „		3	2½
Strip	24	S.W.G. „		3	10½
BS1477. HP30M.					
Plate as rolled		„		2	11
BS1470. HC15WP.					
Sheet	10	S.W.G. „		3	9½
Sheet	18	S.W.G. „		4	2
Sheet	24	S.W.G. „		5	0½
Strip	10	S.W.G. „		3	10½
Strip	18	S.W.G. „		4	2
Strip	24	S.W.G. „		4	9½
BS1477. HPC15WP.					
Plate heat treated		„		3	6½
BS1475. HG10W.					
Wire	10	S.W.G. „		3	10½
BS1471. HT10WP.					
Tubes 1 in. o.d. 16 S.W.G.		„		5	0½
BS1476. HE10WP.					
Sections		„		3	1½
Beryllium Copper					
Strip		„	1	4	11
Rod		„	1	1	6
Wire		„	1	4	9
Brass Tubes		„		1	8⅞
Brazed Tubes		„		—	
Drawn Strip Sections		„		—	
Sheet		ton		—	
Strip		„	241	10	0
Extruded Bar		lb.		1	11½
Extruded Bar (Pure Metal Basis)		„		—	
Condenser Plate (Yellow Metal)		ton	177	0	0
Condenser Plate (Naval Brass)		„	189	0	0
Wire		lb.		2	6⅞
Copper Tubes		lb.		2	1½
Sheet		ton	247	10	0
Strip		„	247	10	0
Plain Plates		„		—	
Locomotive Rods		„		—	
H.C. Wire		„	270	15	0
Cupro Nickel					
Tubes 70/30		lb.		3	5½
Lead Pipes (London)		ton	112	5	0
Sheets (London)		„	110	0	0
Tellurium Lead		„	£6 extra		
Nickel Silver					
Sheet and Strip 7%		lb.		3	6½
Wire 10%		„		4	1½
Phosphor Bronze					
Wire		„		3	11½
Titanium (1,000 lb. lots)					
Billet over 4″ dia.-18″ dia.		lb.	63/-		64/-
Rod 4″ dia.-·250″ dia.		„	75/-		112/-
Wire under ·250″ dia.-·036″ dia.		„	146/-		222/-
Sheet 8′ × 2′ × ·250″-·010″ thick		„	88/-		157/-
Strip ·048″-·003″ thick		„	100/-		350/-
Tube (representative gauge)		„			300/-
Extrusions		„			120/-
Zinc Sheets, English destinations		ton	109	10	0
Strip		„		nom.	

Financial News

Metal Statistics

Detailed figures of the consumption and output of non-ferrous metals for the month of Oct., 1958, have been issued by the British Bureau of Non-Ferrous Metal Statistics, as follow in long tons:—

COPPER	Gross Weight	Copper Content
Wire	30,701	30,294
Rods, bars and sections	13,843	9,103
Sheet, strips and plate	13,803	11,017
Tubes	8,517	7,866
Castings and miscellaneous	7,389	—
Sulphate	3,477	—
	77,730	65,190
Of which:		
Consumption of Virgin Copper		53,937
Consumption of Copper and Alloy Scrap (Copper Content)		11,253

ZINC	
Galvanizing	9,533
Brass	9,240
Rolled Zinc	2,572
Zinc Oxide	2,636
Zinc Die-casting alloy	4,175
Zinc Dust	742
Miscellaneous Uses	940
Total, All Trades	29,838
Of which:	
High purity 99·99 per cent	4,589
Electrolytic and high grade 99·95 per cent	5,808
Prime Western, G.O.B. and debased	11,637
Remelted	541
Scrap Brass and other Cu alloys	4,483
Scrap Zinc, alloys and residues	2,545

ANTIMONY	
Batteries	100
Other Antimonial Lead	39
Bearings	30
Oxides—for White Pigments	115
Oxides—other	84
Miscellaneous Uses	16
Sulphides	8
Total Consumption	392
Antimony in Scrap	
For Antimonial Lead	409
For Other Uses	14
Total Consumption	423

LEAD	
Cables	8,998
Batteries	2,763
Battery Oxides	2,128
Tetra Ethyl Lead	1,845
Other Oxides and Compounds	2,629
White Lead	803
Shot	437
Sheet and Pipe	6,755
Foil and Collapsible Tubes	334
Other Rolled and Extruded	637
Solder	1,190
Alloys	1,671
Miscellaneous Uses	1,166
Total	31,356

CADMIUM	
Plating Anodes	45·50
Plating Salts	7·55
Alloys: Cadmium Copper	4·80
Alloys: Other	3·45
Batteries: Alkaline	4·65
Batteries: Dry	0·35
Solder	5·35
Colours	13·30
Miscellaneous Uses	2·75
Total Consumption	87·70

TIN	
Tinplate	1,080
Tinning:	
Copper Wire	44
Steel Wire	11
All other	69
Solder	205
Alloys	494
Foil and Collapsible Tubes, etc.	51
Tin Compounds and Salts	108
Miscellaneous Uses	10
Total Consumption	2,072

Wolverhampton Die Casting

At the annual general meeting of the Wolverhampton Die Casting Company Ltd., held last week, the chairman, Mr. W. C. Sproson, in the course of his statement, said: "The higher level of demand for the company's products has continued throughout the whole of the past twelve months. As a result, the value of the turnover was an all-time record in the history of the company, increasing by just over 30 per cent as compared with the preceding year. The group profit for the year amounted to £177,145, compared with £102,518 for the preceding year.

The taxation provisions are £91,911, which is almost double the figure for the preceding year, and is due in the main to the transfer to taxation equalization reserve, which is to adjust the capital allowances which are now allowed and will be added back over future years. The directors recommend a final dividend of 20 per cent, less income tax, on the Ordinary shares, making 30 per cent for the year, as compared with 25 per cent for last year.

David Brown Group

Group net profits, subject to audit, of £234,334 for the year to June 30 last, compared with £177,750 for 1956-57 and with £108 for the preceding year are reported by the David Brown Corporation.

Deducting outside interests, the profit balance attributable to the company is £234,780, against £178,923.

Scrap Metal Prices

Merchants' average buying prices delivered, per ton, 22/12/58.

	£
Aluminium	
New Cuttings	142
Old Rolled	120
Segregated Turnings	90
Brass	
Cuttings	138
Rod Ends	132
Heavy Yellow	105
Light	100
Rolled	128
Collected Scrap	103
Turnings	126
Copper	
Wire	190
Firebox, cut up	182
Heavy	178
Light	173
Cuttings	190
Turnings	170
Braziery	145
Gunmetal	
Gear Wheels	170
Admiralty	170
Commercial	148
Turnings	143
Lead	
Scrap	61
Nickel	
Cuttings	—
Anodes	500
Phosphor Bronze	
Scrap	148
Turnings	143
Zinc	
Remelted	54
Cuttings	42
Old Zinc	31

The latest available scrap prices quoted on foreign markets are as follow. (The figures in brackets give the English equivalents in £1 per ton):—

West Germany (D-marks per 100 kilos):		
Used copper wire	(£182.15.0)	210
Heavy copper	(£182.15.0)	210
Light copper	(£152.5.0)	175
Heavy brass	(£104.10.0)	120
Light brass	(£82.12.6)	95
Soft lead scrap	(£58.5.0)	67
Zinc scrap	(£38 5.0)	44
Used aluminium unsorted	(£87.0.0)	100
France (francs per kilo):		
Copper	(£204.10.0)	235
Heavy copper	(£204.10.0)	235
Light brass	(£134.17.6)	155
Zinc castings	(£58.5.0)	67
Lead	(£81.15.0)	94
Tin	—	
Aluminium	(£117.10.0)	135

Italy (lire per kilo):		
Aluminium soft sheet clippings (new)	(£194.7.6)	335
Aluminium copper alloy	(£124.15.0)	215
Lead, soft, first quality	(£83.10.0)	144
Lead, battery plates	(£47.10.0)	82
Copper, first grade	(£200.2.6)	345
Copper, second grade	(£188.10.0)	325
Bronze, first quality machinery	(£197.5.0)	340
Bronze, commercial gunmetal	(£168.5.0)	290
Brass, heavy	(£136.7.6)	235
Brass, light	(£124.15.0)	215
Brass, bar turnings	(£127.12.6)	220
New zinc sheet clippings	(£58.0.0)	100
Old zinc	(£43.10.0)	75

THE STOCK EXCHANGE

Business Slower With Approach Of Holiday But Prices Maintained

ISSUED CAPITAL *	AMOUNT OF SHARE	NAME OF COMPANY	MIDDLE PRICE 19 DECEMBER +RISE —FALL	DIV. FOR LAST FIN. YEAR	DIV. FOR PREV. YEAR	DIV. YIELD	1958 HIGH	1958 LOW	1957 HIGH	1957 LOW
£	£			Per cent	Per cent					
4,435,792	1	Amalgamated Metal Corporation ...	23/6	9	10	7 13 3	24/9	17/6	28/3	18/–
400,000	2/–	Anti-Attrition Metal	1/7½	4	8½	4 18 6	1/9	1/3	2/6	1/6
38,305,038	Stk. (£1)	Associated Electrical Industries ...	57/9 —3d.	15	15	5 3 9	58/9	46/6	72/3	47/9
1,590,000	1	Birfield	56/6	15	15	5 6 3	62/4½	46/3	70/–	48/9
3,196,667	1	Birmid Industries	69/– +2/3	17½	17½	5 1 6	77/6	55/3	80/6	55/9
5,638,344	Stk. (£1)	Birmingham Small Arms	36/6 +1/–	11	10	6 0 6	37/3	23/9	33/–	21/9
203,150	Stk. (£1)	Ditto Cum. A. Pref. 5%	15/–	5	5	6 13 3	16/1½	14/7½	16/–	15/–
350,580	Stk. (£1)	Ditto Cum. B. Pref. 6%	17/1½	6	6	7 0 3	17/4½	16/6	19/–	16/6
500,000	1	Bolton (Thos.) & Sons	26/9	10	12½	7 9 6	28/9	24/–	30/3	28/9
300,000	1	Ditto Pref. 5%	15/–	5	5	6 13 3	16/–	15/–	16/9	14/3
160,000	1	Booth (James) & Co. Cum. Pref. 7%	19/6xd	7	7	7 3 6	20/4½	19/–	22/3	18/9
9,000,000	Stk. (£1)	British Aluminium Co.	73/3 +1/3	12	12	3 5 6	74/–	36/6	72/–	38/3
1,500,000	Stk. (£1)	Ditto Pref. 6%	19/6	6	6	6 3 0	20/–	18/4½	21/6	18/–
15,000,000	Stk. (£1)	British Insulated Callender's Cables	52/– +9d.	12½	12½	4 16 3	52/–	38/9	55/–	40/–
17,047,166	Stk. (£1)	British Oxygen Co. Ltd., Ord. ...	45/7½ +1/4½	10	10	4 7 6	47/–	28/3	39/–	29/6
600,000	Stk. (5/–)	Canning (W.) & Co.	24/6	25+ *2½C	25	5 2 0	24/6	19/7½	24/6	19/3
60,494	1/–	Carr (Chas.)	1/3	25	25	20 0 0	2/3	1/4½	3/6	2/1½
150,000	2/–	Case (Alfred) & Co. Ltd.	4/9xd	25	25	10 5 3	5/3	4/–	4/6	4/–
555,080	1	Clifford (Chas.) Ltd.	22/– +6d.	10	10	9 1 9	22/–	16/–	20/6	15/9
45,000	1	Ditto Cum. Pref. 6%	15/3xd	6	6	7 17 6	16/–	15/–	17/6	16/–
250,000	2/–	Coley Metals	2/9 —3d.	20	25	14 11 0	4/6	2/6	5/7½	3/9
8,730,596	1	Cons. Zinc Corp.†	59/– —6d.	18‖	22½	6 6 6	59/6	41/–	92/6	49/–
1,136,233	1	Davy & United	85/6 +9d.	20	15	4 13 6	85/6	45/9	60/6	42/6
2,750,080	5/–	Delta Metal	24/9 +1½d.	30	*17½	6 1 3	25/–	17/7½	20/6	19/–
4,160,000	Stk. (£1)	Enfield Rolling Mills Ltd.	35/– +6d.	12½	15B	7 3 0	38/–	22/9	38/6	25/–
750,000	1	Evered & Co.	30/–	15Z	15	6 13 3	30/–	26/–	52/9	42/–
18,000,000	Stk. (£1)	General Electric Co.	39/3	10	12½	5 2 0	40/3	29/6	59/–	38/–
1,500,000	Stk. (10/–)	General Refractories Ltd.	36/3	20	17½	5 10 3	39/3	27/3	37/–	26/9
401,240	1	Gibbons (Dudley) Ltd.	66/6xd	15	15	4 10 3	67/6	61/–	71/–	53/–
750,000	5/–	Glazier Metal Co. Ltd.	7/– —3d.	11½	11½	8 4 3	8/3	5/–	8/1½	5/10½
1,750,000	5/–	Glynwed Tubes	15/'0½ —1½d.	20	20	6 6 0	18/1½	12/10½	18/–	12/6
5,421,049	10/–	Goodlass Wall & Lead Industries ...	30/–	13‖	18Z	4 6 9	30/–	17/3	37/3	28/9
342,195	1	Greenwood & Batley	57/6	20	17½	6 19 3	57/9	45/–	50/–	46/–
396,000	5/–	Harrison (B'ham) Ord.	15/4½	*15	*15	4 17 6	15/9	11/6	16/9	12/4½
150,000	1	Ditto Cum. Pref. 7%	19/6xd	7	7	7 3 6	19/9	18/4½	22/3	18/7½
1,075,167	5/–	Heenan Group	7/9	10	10‡	6 9 0	9/7½	6/9	10/4½	6/9
236,953,260	Stk. (£1)	Imperial Chemical Industries ...	35/4½ +4½d.	12Z	10	4 8 0	36/7½	27/7½	46/6	36/3
33,708,769	Stk. (£1)	Ditto Cum. Pref. 5%	16/6 —3d.	5	5	6 1 3	17/1½	16/–	18/6	15/6
14,584,025	**	International Nickel	158 +3¢	$2.60	$3.75	2 19 3	169	132½	222	130
430,000	5/–	Jenks (E. P.), Ltd.	9/9xd	14	27½◊	7 3 6	9/9	6/7½	18/10½	15/1½
300,000	1	Johnson, Matthey & Co. Cum. Pref. 5%	15/7½	5	5	6 8 0	16/9	15/–	17/–	14/6
3,987,435	1	Ditto Ord.	45/6 +3d.	10	10	4 8 0	47/–	36/6	58/9	40/–
600,000	10/–	Keith, Blackman	28/9	17½	15	6 1 9	28/9	15/–	21/9	15/–
160,000	4/–	London Aluminium	5/9xd +3d.	10	10	6 19 3	5/9	3/–	6/9	3/6
2,400,000	1	London Elec. Wire & Smith's Ord. ...	62/6 +2/6	12½	12½	4 0 0	64/6	39/9	54/6	41/–
400,000	1	Ditto Pref.	23/7½	7½	7½	6 7 0	24/3	22/–	25/3	21/9
765,012	1	McKechnie Brothers Ord.	45/–	15	15	6 13 3	45/–	32/–	48/9	37/6
1,530,024	1	Ditto A Ord.	45/–	15	15	6 13 3	45/–	30/–	47/6	36/–
1,108,268	5/–	Manganese Bronze & Brass	13/–	20	27½‡	7 13 9	14/1½	8/9	21/10½	7/6
50,628	6/–	Ditto (7½% N.C. Pref.)	6/–	7½	7½	7 10 0	6/3	5/6	6/6	5/–
13,098,853	Stk. (£1)	Metal Box	69/4½ +10½d.	11	11	3 0 6	69/4½	40/6	59/–	40/3
415,760	Stk. (2/–)	Metal Traders	8/9	50	50	11 8 6	9/–	6/3	8/–	6/3
160,000	1	Mint (The) Birmingham	21/– +6d.	10	10	9 10 6	22/9	19/–	25/–	21/6
80,000	5	Ditto Pref. 6%	70/6	6	6	8 10 3	83/6	69/–	90/6	83/6
3,705,670	Stk. (£1)	Morgan Crucible A	43/6 +6d.	10	10	4 12 0	45/–	34/–	54/–	35/–
1,000,000	Stk. (£1)	Ditto 5½% Cum. 1st Pref. ...	17/9 +3d.	5½	5½	6 4 0	18/–	17/–	19/3	16/–
2,200,000	Stk. (£1)	Murex	46/– —6/–	17½	20	7 12 3	58/9	46/–	79/9	57/–
468,000	5/–	Ratcliffs (Great Bridge)	11/–	10	10	4 11 0	11/1½	6/10½	8/–	6/10½
234,960	10/–	Sanderson Bros. & Newbould ...	27/3	20	27½D	7 6 9	27/3	24/6	41/–	24/9
1,365,000	Stk. (5/–)	Serck	18/1½ +1½d.	15	17½	4 2 9	18/4½	11/–	18/10½	11/6
6,698,586	Stk. (£1)	Stone-Platt Industries	44/–	15	12½	6 16 3	44/6	22/6	33/4½	22/7½
2,928,963	Stk. (£1)	Ditto 5½% Cum. Pref.	15/9 —6d.	5½	5½	6 19 9	16/3	12/7½	14/–	12/9
14,494,252	Stk. (£1)	Tube Investments Ord.	78/6	17½	15	4 9 3	70/9	43/4½	70/9	50/6
41,000,000	Stk. (£1)	Vickers	34/6	10	10	5 16 0	36/3	28/9	46/–	29/–
750,000	Stk (£1)	Ditto Pref. 5%	15/– —6d.	5	5	6 13 3	15/9	14/3	18/–	14/–
6,853,897	Stk. (£1)	Ditto Pref. 5% tax free	22/–	*5	*5	7 0 3A	23/–	21/3	24/9	20/7½
2,200,000	1	Ward (Thos. W.), Ord.	85/3 +1/3	20	15	4 13 9	87/3	70/9	83/–	64/–
2,666,034	Stk. (£1)	Westinghouse Brake	44/6 +1/–	10	18P	4 10 0	44/6	32/6	85/–	29/1½
225,000	2/–	Wolverhampton Die-Casting ...	9/–xd	30	25	6 13 3	10/1½	7/–	10/1½	7/–
591,000	5/–	Wolverhampton Metal	21/3	27½	27½	6 9 6	22/9	14/9	22/3	14/9
78,465	2/6	Wright, Bindley & Gell	5/3 —1½d.	20	20	9 10 6	5/4½	2/9	3/9	2/7½
124,140	1	Ditto Cum. Pref. 6%	12/9xd	6	6	9 8 3	13/–	11/3	12/6	11/3
150,000	1/–	Zinc Alloy Rust Proof	2/9	27	48D	9 16 3	3/1½	2/7½	5/–	2/9

*Dividend paid free of Income Tax. †Incorporating Zinc Corpn. & Imperial Smelting. **Shares of no Par Value. ‡ and 100% Capitalized issue. ◊ The figures given relate to the issue quoted in the third column. A Calculated on £7 14 6 gross. Y Calculated on 11½% dividend. ‖Adjusted to allow for capitalization issue. E for 15 months. P and 100% capitalized issue, also "rights" issue of 2 new shares at 35/– per share for £3 stock held. D and 50% capitalized issue Z and 50% capitalized issue. B equivalent to 12½% on existing Ordinary Capital after 100% capitalized issue. ◊ And 100% capitalized issue. X Calculated on 17½%. C Paid out of Capital Profits.

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